NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

REPORT 1214

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By NORMAN S. SILSBY

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STATISTICAL MEASUREMENTS OF CONTACT CONDITIONS OF 478 TRANSPORT-AIRPLANE LANDINGS DURING ROUTINE DAYTIME OPERATIONS [1]

By Norman S. Silsby

SUMMARY

Statistical measurements of contact conditions have been obtained, by means of a special photographic technique, of 478 landings of present-day transport airplanes made during routine daylight operations in clear air at the Washington National Airport. From these measurements, sinking speeds, rolling velocities, bank angles, and horizontal speeds at the instant before contact have been evaluated and a limited statistical analysis of the results has been made.

The analysis indicates that, for transport airplanes in general, the gusty-wind condition had a substantial effect in increasing the values of sinking speed, bank angle, and rolling velocity likely to be equaled or exceeded once for a given number of landings but had essentially no effect on the airspeeds at contact. Specifically, in 1,000 landings under conditions of no gusts, the values of sinking speed, bank angle, and rolling velocity (in the direction of the first wheel to touch) likely to be equaled or exceeded once are 3.5 ft/sec, 4.8°, and 4.4 deg/sec, respectively; for the same probability of 1 out of 1,000 landings made under conditions with gusts, the values of these respective quantities increase to 4.7 ft/sec, 6.6°, and 5.3 deg/sec. In general, the transport airplanes landing at Washington National Airport touch down at airspeeds which have a considerable margin above the stall; in 1 out of 1,000 landings, the landing speed will probably equal or exceed an airspeed 60 percent above the stalling speed (based on an assumed loading of 0.9 of the maximum permissible landing weight).

Although wing loading was seen to have some effect on the sinking speeds of various transport airplanes, that is, there was a tendency for airplanes with higher wing loading to land with higher sinking speeds, the actual correspondence was rather poor, and study of a greater number of landings is required in order to isolate the influence of wing loading and other parameters which cause the differences in sinking speeds for the various types of airplanes.

INTRODUCTION

At the present time, airplanes and their landing gears are being designed to satisfy landing-loads requirements which are based on experience with earlier airplanes. Design procedures also are based largely on past experience. The sizes and speeds of airplanes have steadily increased, with associated changes in structural flexibility, weight distribution, landing speeds, and other characteristics, since these design procedures and requirements were established. For this reason and as a result of the increased economic pressure toward a reduction in weight, it has become necessary to reexamine the landing-loads problem in order to establish up-to-date requirements and design procedures that will insure safety with the least possible cost in weight.

The first step in developing more rational landing-loads requirements is to obtain information on the severity and frequency of the load-producing conditions likely to be encountered by an airplane in landing. The conditions which produce or influence the loads on the landing gear and airplane structure are the sinking speed, horizontal speed, attitude angles, angular velocities, and so forth, which exist at the instant of touchdown. Inasmuch as many indeterminate factors influence these quantities, they must be treated as a statistical problem. For the case of aircraft-carrier operations, a substantial amount of statistical information on landing approach conditions has been obtained by the Navy and is being augmented continually. For land-based operations, on the other hand, very little suitable information is available, particularly for operations of present-day transport airplanes.

The National Advisory Committee for Aeronautics has undertaken the project of obtaining statistical measurements of landing contact conditions for present-day transport airplanes during routine operations. The equipment for obtaining the measurements was set up at the Washington National Airport in the middle of January 1953, with the permission and cooperation of the airport authorities. From that time until the middle of April 1953, in about 56 hours of operation (during portions of 15 different days), a total of 630 airplane landings were photographed and, of these, 478 were suitable for evaluation and analysis.

Preliminary results for the first 126 usable landings (the first 20 hours of operation), together with a brief statistical analysis, have been reported in reference 1. These 126 landings also are included in the analysis of the 478 landings reported herein. Photographs were obtained for the landings of varieties of present-day twin-engine and four-engine airplanes. From these records, sinking speeds, horizontal speeds, bank angles, and rolling velocities have been evaluated and a limited statistical analysis of the results has been made.

[1] Supersedes NACA TN 3194, 1954.

APPARATUS AND METHOD

A photograph of the equipment used for obtaining statistical data on the landing contact conditions is shown as figure 1. The equipment consists essentially of a constant-speed 35-millimeter motion-picture camera fitted with a telephoto lens of 40-inch focal length, supported on a vertical shaft which provides for tracking the airplane only in azimuth. The trailer on which the equipment is mounted can be raised on jacks to permit very accurate leveling of the camera and provide a rigid support. Since no instruments are installed in the airplanes, pilots are unaware that landings are being monitored. The camera was set up at a distance of 800 to 1,000 feet from the runway so that it offered no obstruction to aircraft on the airport proper. All the data in the present analysis were obtained from photographs of landings made at Washington National Airport on a runway which is 5,210 feet long and extends from a southeasterly to a northwesterly direction.

The sinking speed for each of the two wheels of the main landing gear is determined from a consideration of the range and the time rate of change of wheel location, which in turn is obtained by measuring the change in image-wheel position over a 5-frame interval (4 time intervals) immediatly prior to first-wheel contact. The camera runs at an accurately controlled rate of 25 frames per second; thus, the sinking speed (as well as the other quantities) is determined over a time interval of $\frac{4}{25}$ second prior to contact, which corresponds to a vertical height of about $\frac{1}{3}$ foot for a sinking speed of 2 ft/sec. The formula used to determine vertical velocity for each of the main-gear wheels is given in reference 2 along with its derivation and the corrections to be applied. The average of the sinking speeds for the two main-gear wheels is considered to be the sinking speed for the airplane center of gravity. Some center-of-gravity sinking speeds were obtained by reading a point on the fuselage near the center of gravity for those landings in which both wheels were not visible.

The rolling velocity of the airplane is determined from a consideration of the known wheel tread and the difference in the values of sinking speed for the two wheels. The roll-attitude angle, or bank angle, at the instant of contact is determined from the relative vertical positions of the wheel images, together with the range and wheel tread, according to the formula:

$$\phi=\frac{180}{\pi f}\left[(h_l-h_r)\,\frac{D}{T\cos\theta}-\left(d-\frac{h_l+h_r}{2}\right)\cos\theta\right]$$

where

- d distance from film-frame reference to optical center of frame, 0.536 in.
- D perpendicular distance to center line of runway from camera, 795 ft
- f lens focal length, 40 in.
- h_l distance from film-frame reference to left wheel, in.
- h_r distance from film-frame reference to right wheel, in.
- T airplane main-axle wheel tread, ft
- θ azimuth angle at camera between D and line to airplane wheels at time of contact, deg
- ϕ bank angle, deg (positive for right bank)

The photograph in figure 2 is a sample frame from a landing sequence and illustrates the appearance of the record for a relatively large roll angle at contact (5.5°). The instant of contact can usually be determined readily by the puff of smoke from the tire. The spot of light appearing in the center of this figure is produced by instrumentation in the camera which denotes the azimuth angle for use in evaluating the data and is not due to any installation in the airplane.

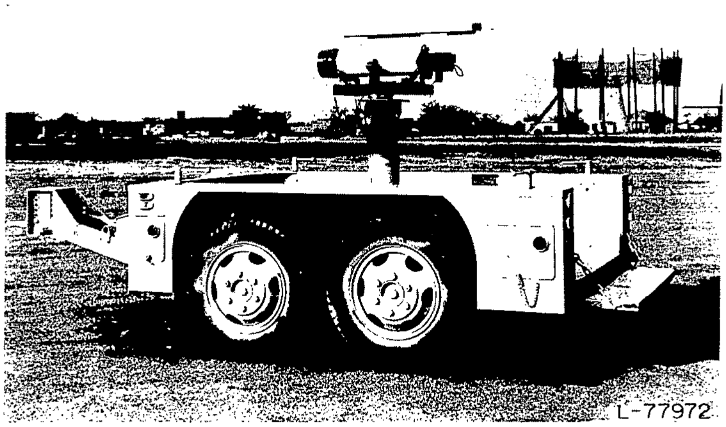


FIGURE 1.—Equipment for measuring landing contact conditions.

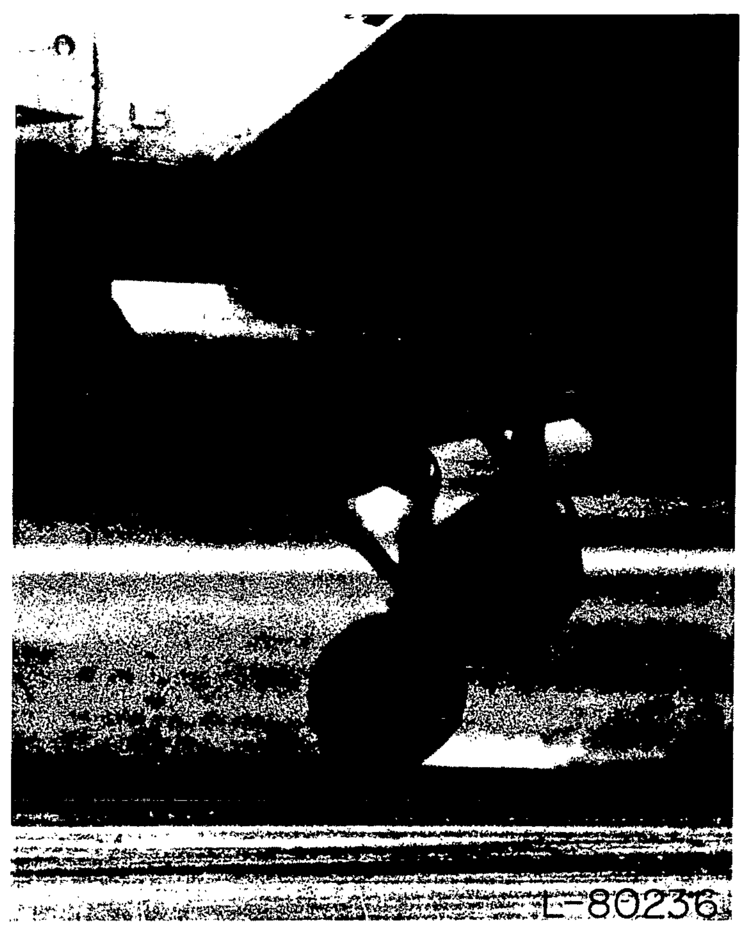


FIGURE 2.—Sample frame from landing sequence showing smoke puff at tire contact.

Horizontal velocities are determined from the change in position of the airplane image with respect to the image of a stationary background object appearing in two or more successive frames according to the equation:

$$V_H = \frac{D}{f \cos^2 \theta'} \frac{\Delta h}{\Delta t}$$

where

- Δh change in distance on film from airplane image to image of background object, in.
- Δt time interval corresponding to Δh, sec
- V_H horizontal velocity, ft/sec
- θ' azimuth angle at camera between line of D and line to airplane center of gravity at time of frames in which Δh was measured.

Horizontal velocities were determined as closely as possible to the time of contact; in no case did the time exceed ½ second prior to contact. Because the longitudinal deceleration immediately prior to contact normally will be about $0.1g$, the horizontal velocity ½ second before contact would be about 1½ ft/sec higher than the actual velocity at contact. A more complete and detailed description of the apparatus and equipment, considerations in design, method of operation, and data reduction can be found in reference 2.

Landings were photographed for twelve present-day twin-engine and four-engine airplanes; general specification data for these airplanes are given in table I.

ACCURACY

The accuracy in terms of probable error in the quantities determined as a result of errors in film reading and the error introduced by neglecting the vertical acceleration is as follows:

Sinking speed, ft/sec	±0.1
Rolling velocity, deg/sec	±¼
Bank angle, deg	≦±0.1
Horizontal velocity, ft/sec	±1.5

For a more detailed account of sources of error and accuracy of the results, especially with regard to sinking speed, see reference 2.

PRESENTATION OF RESULTS

The values of sinking speed, forward ground speed, bank angle, rolling velocity, and other pertinent data are listed in table II for each of the 478 airplane landings. The statistical analysis of these results is presented in terms of frequency distributions (figs. 3 and 4) and probability curves (figs. 5 to 11). The data have been analyzed as a whole as well as grouped according to landings with and without gusts, where the gusty condition is defined (according to ref. 3) as sudden, intermittent increases in speed with at least a 10-mph (9-knot) variation between peaks and lulls. The peaks must reach at least 18 mph (16 knots), and the average time interval between peaks and lulls should usually not exceed 20 seconds.

The Pearson type III probability curves were determined in the manner described in reference 4. Values of the statistical parameters (mean value, standard deviation σ, and coefficient of skewness α_3) for sinking speed, bank angle, rolling velocity, and airspeed at contact, which are used in the determination of the probability curves, are listed in table III for the various airplane categories and gust conditions. These curves, which fit the data reasonably well, provide a systematic fairing of the data and permit some extrapolation, which gives an indication of the magnitudes of the various quantities likely to be encountered in a greater number of landings than were actually observed.

The stalling speeds used in this evaluation were taken from flight manuals of the various airplanes or from the available test results for the landing configuration, with the arbitrary assumption that the landing weight was 90 percent of the maximum permissible landing weight. The airspeed was determined as the sum of the measured horizontal speed and the parallel component (in the direction of the runway) of wind velocity measured at the control tower.

STATISTICAL ANALYSIS AND DISCUSSION

SINKING SPEED

The frequency distributions of sinking speed for the center of gravity and the first wheel to touch (fig. 3) are very similar and indicate no significant difference in the statistics of these quantities. Only sinking-speed data pertaining to the center of gravity of the airplane therefore are presented in the rest of the report, and these data may be considered to apply to either the center of gravity or the first wheel to touch.

TABLE I.—GENERAL SPECIFICATION DATA FOR TRANSPORT AIRPLANES

Airplane	Type of transport airplane	Maximum gross weight, lb	Wing area, sq ft	Maximum wing loading, lb/sq ft	Maximum permissible landing weight, lb	Stalling speed for 0.9 maximum landing weight, mph	Main-axle wheel tread, ft	Maximum lift coefficient, landing condition
A	Twin-engine	17,500	545	32.0	15,000	67	15	2.12
B	Twin-engine	27,000	988	27.3	25,000	67	18.5	1.96
C	Twin-engine	31,000	970	32.0	29,000	72	18.5	2.04
D	Twin-engine	45,000	1,360	33.0	45,000	72	26	2.29
E	Twin-engine	42,750	906	47.2	42,000	83	25	2.78
F	Four-engine	73,000	1,463	49.8	63,500	80	26	2.42
G	Twin-engine	41,790	817	51.1	39,800	85	25.5	2.36
H	Four-engine	107,000	1,650	64.9	85,500	85	28	2.54
I	Four-engine	120,000	1,650	72.7	98,000	90	28	2.54
J*	Four-engine	88,000	1,463	60.0	75,000	84	26	2.57
J*	Four-engine	103 000	1,463	70.4	88,000	90	26	2.60
K	Four-engine	142,500	1,769	80.5	121,700	98	28.5	2.42

*Average of specification data for these two transport airplanes used in analysis.

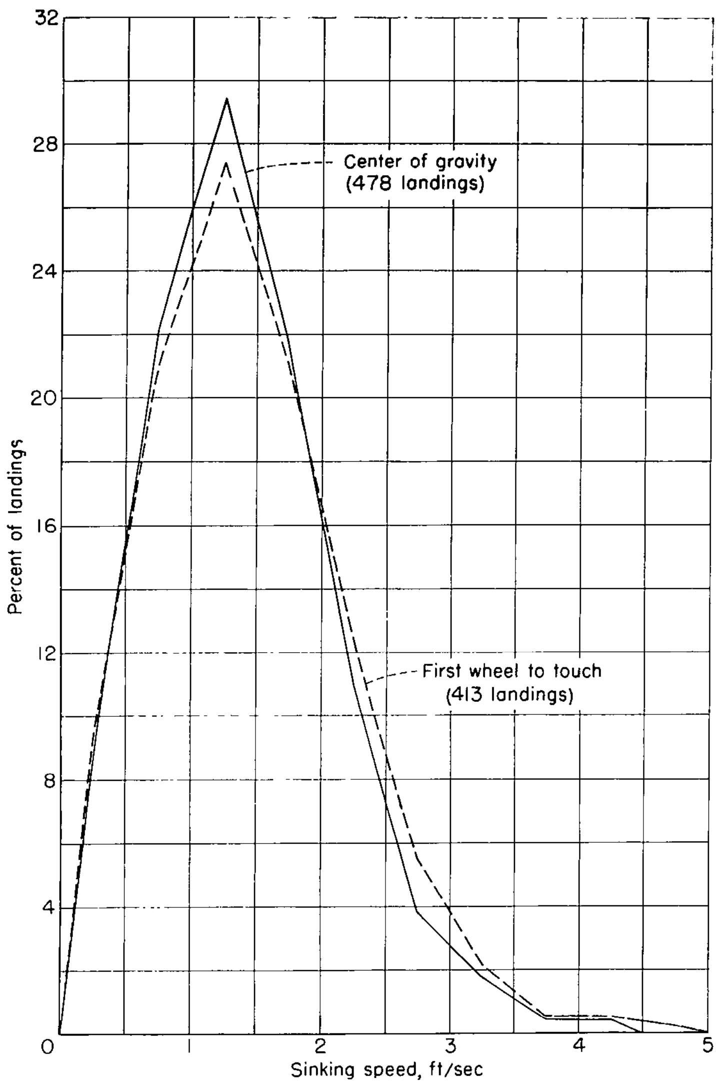


FIGURE 3.—Comparison of frequency distributions of sinking speeds for center of gravity and first wheel to touch.

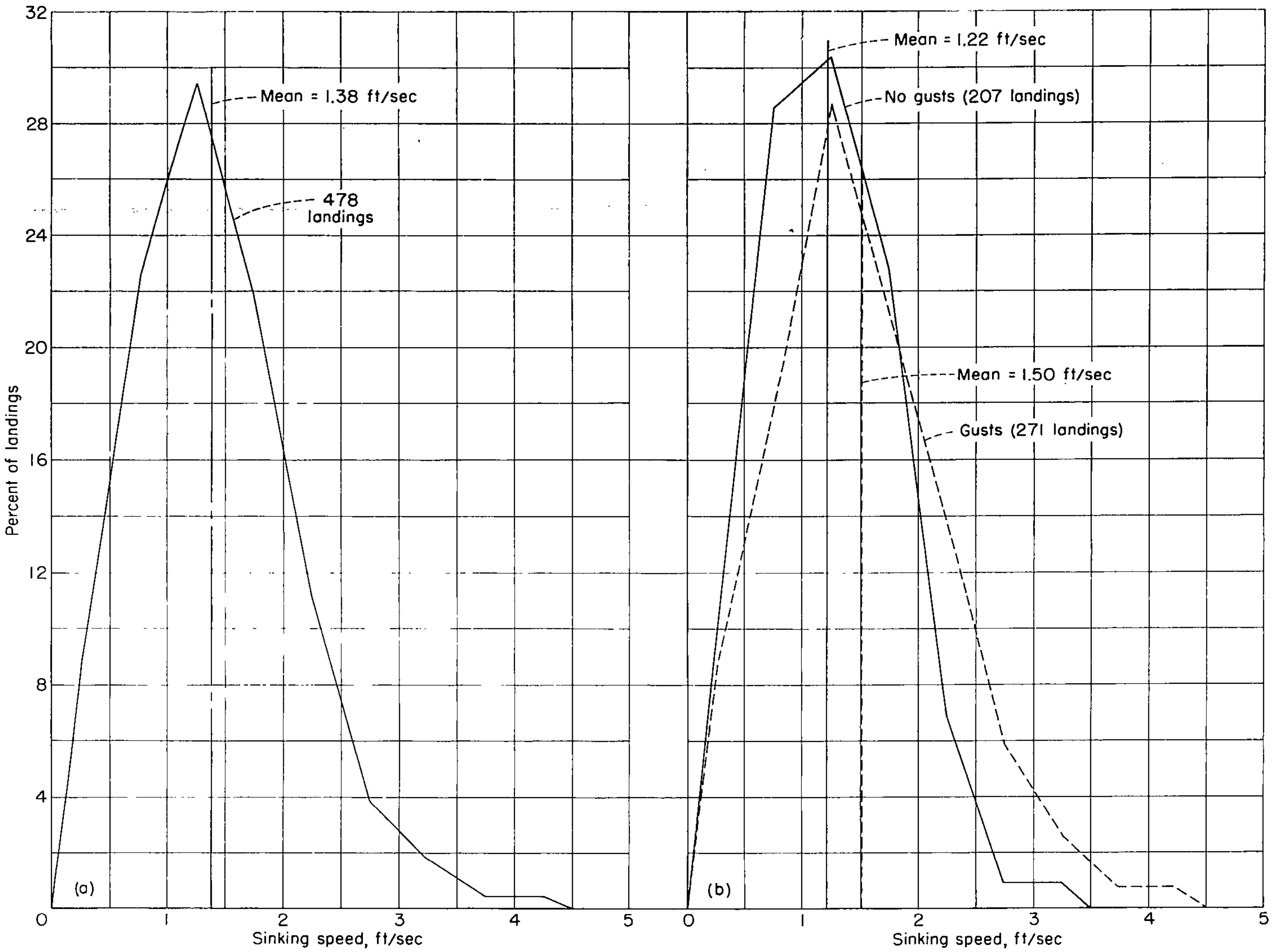
The frequency distributions of the percentage of landings occurring in various 0.5-ft/sec ranges of sinking speeds (fig. 4(a)) show that the greatest percentage (29.5 percent or 141) of the landings occurred in the range from 1.0 to 1.5 ft/sec. The mean for all 478 landings was 1.38 ft/sec, and no landings exceeded a sinking speed of 4.5 ft/sec. A comparison of frequency distributions of sinking speeds for conditions of gusts (271 landings) and no gusts (207 landings) indicates the marked effect of gusty conditions on sinking speed (fig. 4(b)). Although the greatest percentages of landings for the gusty condition (28.7 percent) and the no-gust condition (30.4 percent) occurred in the same range of sinking speed (1.0 to 1.5 ft/sec), substantially greater numbers of landings are shown to occur at lower sinking speeds for conditions of no gusts than for gusty conditions. At the higher sinking speeds, a greater number of landings occur for the gust condition than for the no-gust condition. The mean value of all sinking speeds for conditions of no gusts was 1.22 ft/sec, and the standard deviation was 0.57 ft/sec; the mean of all sinking speeds measured in gusty-wind conditions was 1.50 ft/sec, and the standard deviation was 0.76 ft/sec. No landing exceeded a sinking speed of 3.4 ft/sec for conditions without gusts; the maximum value of sinking speed attained during gusty conditions was 4.5 ft/sec. The wind velocity (measured at the control tower) for conditions of no gusts ranged up to 18 mph with cross-wind components (at 90° with respect to the direction of the runway) up to 11 mph. For the gusty condition, the mean wind speeds ranged from 14 to 28 mph with gust velocities up to 38 mph and cross winds up to 17 mph. It cannot be definitely stated, therefore, that the differences shown are due solely to gustiness, inasmuch as the associated higher winds and higher cross winds may also have some influence.

Although the difference in mean values of sinking speed between the landings with gusts (1.50 ft/sec) and the landings without gusts (1.22 ft/sec) was only of the order of 1/4 ft/sec (fig. 4(b)) for this number of landings, the difference was significant according to a method of statistical analysis concerning significant differences in variables (ref. 5). The difference in standard deviations from the means was also significant.

The probability curves of sinking speeds for all airplane landings are shown in figure 5 and indicate in a more graphic manner the effect of gusty conditions, as compared to the no-gust condition, on the probability of occurrence of various sinking speeds. For example, the curve for the condition without gusts, under which 207 observations were made, indicates that a sinking speed of 3.5 ft/sec would be expected to be equaled or exceeded once in about 1,000 landings; the curve for gusty conditions (271 landings) indicates that the same sinking speed (3.5 ft/sec) should be equaled or exceeded once in only about 60 landings. For gusty conditions, a value of sinking speed of 4.7 ft/sec would be equaled or exceeded once in 1,000 landings. The curve for all landings, which combined the conditions of gusts and no gusts in a relative frequency of occurrence of about 3 to 2, indicates that 3.5 ft/sec will probably be equaled or exceeded once in about 150 landings.

For six types of airplanes, the probability curves of sinking speed based on 36 to 100 observations per type indicate substantial differences in the probability of equaling or exceeding a given sinking speed (fig. 6). These probability curves for the various individual transport types are preliminary and should be considered to indicate trends only, in view of the relatively small number of landings for the different types. A comparison of the probability curves of sinking speed determined from the data of the first 60 landings for all airplanes, and then, successively, for 126, 243, and 478 landings, as more landings were photographed, indicated that probably on the order of 200 landings are required to establish a probability curve which would have a practical degree of reliability.

One factor which was thought to be particularly responsible for the difference in sinking-speed statistics for the various types of airplanes was the wing loading. Actually, the correlation between sinking speeds and wing loading is rather poor (see table I and fig. 6). Airplane B which has the lowest wing loading exhibited the lowest sinking speeds, but, among the rest of the airplanes, no apparent relationship



(a) Total landings. (b) With and without gusts.

FIGURE 4.—Frequency distributions of center-of-gravity sinking speeds of transport airplanes during routine operations for all 478 landings and for conditions of no gusts (207 landings) and gusts (271 landings).

existed between wing loading and sinking speeds. In an attempt to suppress the influence of factors associated with individual airplanes which might mask the effect of wing loading, the data were grouped into categories of low, medium and high wing loading. The groupings were as follows: The low-wing-loading group included airplane types A, B, C, and D with a range of gross-weight wing loadings of 27 to 33 lb/sq ft; the medium-wing-loading group included airplane types E, F, and G with a wing-loading range from 47 to 51 lb/sq ft; and the high-wing-loading group included airplane types H, I, J, and K with a range of wing loading of 65 to 80 lb/sq ft. The probability curves of sinking speed according to the above groupings (fig. 7) indicate a tendency toward substantiating the assumption that a given sinking speed more probably will be equaled or exceeded for a more highly loaded airplane, but the correspondence is still not complete. The curve for the low-wing-loading group indicates the lowest probability for a given sinking speed. However, the medium- and high-wing-loading groups are reversed from the presumed order; that is, the medium-wing-loading group indicates a higher probability of equaling or exceeding a given sinking speed than the high-wing-loading group. It appears that, although the effect of increasing the wing loading above about 30 lb/sq ft tends at first to increase the probability of equaling or exceeding a given sinking speed, a point is reached beyond which other factors such as pilot technique, airline policy, airplane handling qualities, and so forth, become predominant and offset any further direct correspondence between sinking-speed probability and wing loading. It should be pointed out that all the airplanes in the low-wing-loading group had conventional landing gears, whereas the aircraft in the medium- and high-wing-loading groups had gears of the tricycle type.

The effect of gusts on the probability of equaling or exceeding a given sinking speed for the medium- and high-wing-loading groups is similar to that found previously for the total airplane-landing population (fig. 5); that is, gusty conditions increased the probability of equaling or exceeding a given sinking speed. However, for the low-wing-loading group, there was, essentially, no effect due to gusts.

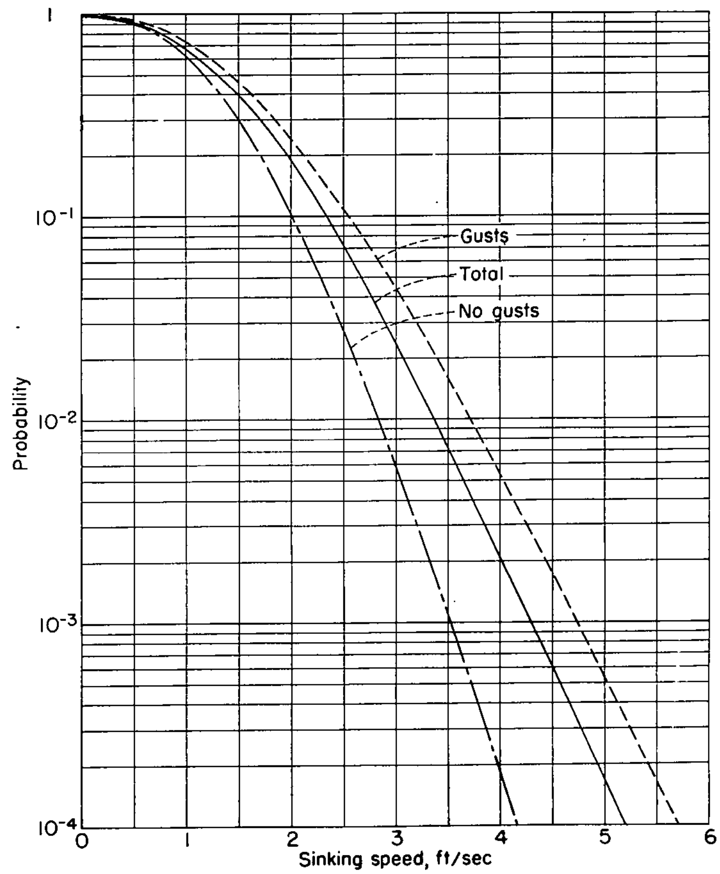


FIGURE 5.—Probability of equaling or exceeding sinking speed for conditions of gusts, no gusts, and total landings.

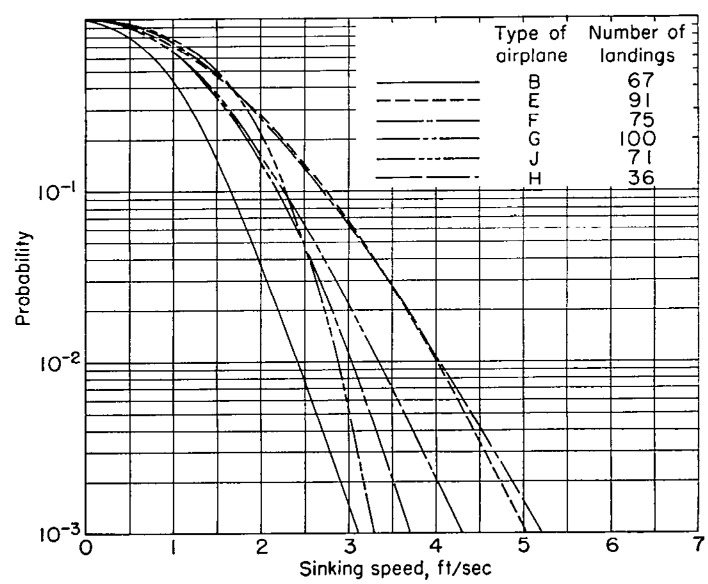
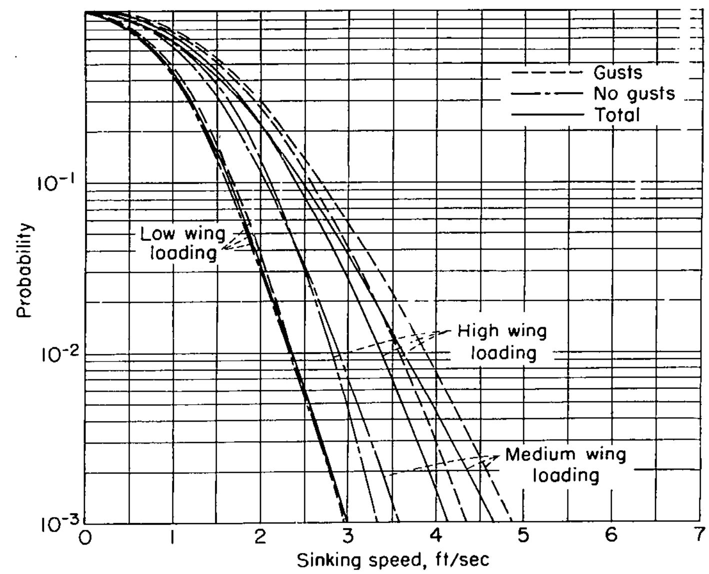


FIGURE 6.—Probability of equaling or exceeding sinking speed for six types of airplanes.



Landing condition	Number of landings		
	Low wing loading	Medium wing loading	High wing loading
Gusts	45	148	78
No gusts	47	118	42
Total	92	266	120

FIGURE 7.—Probability of equaling or exceeding sinking speed for airplanes of low, medium, and high wing loadings and for conditions of gusts, no gusts, and total landings.

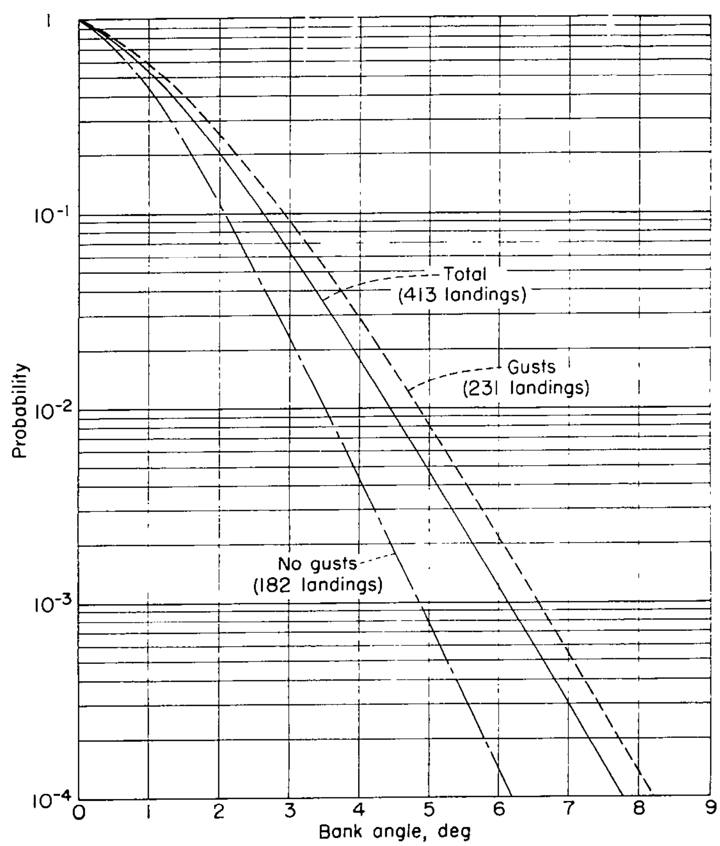
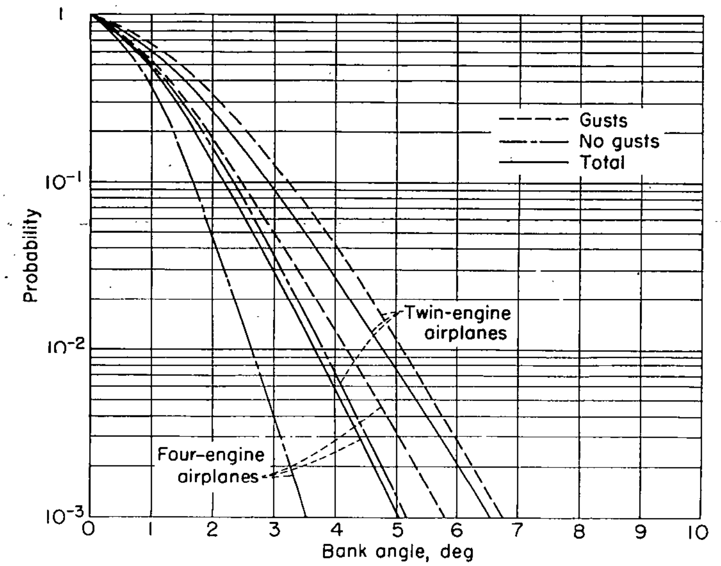
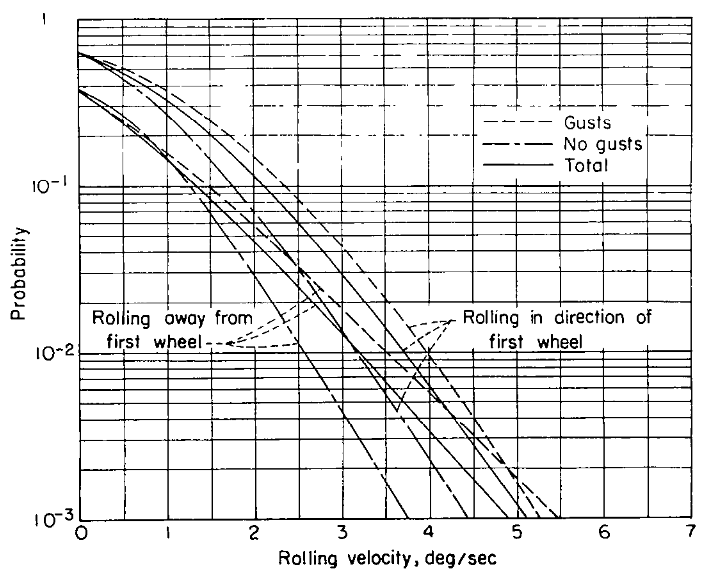


FIGURE 8.—Probability of equaling or exceeding bank angle for conditions of gusts, no gusts, and total landings.



Landing condition	Number of landings	
	Twin-engine airplanes	Four-engine airplanes
Gusts	132	99
No gusts	110	72
Total	242	171

FIGURE 9.—Probability of equaling or exceeding bank angle for twin-engine and four-engine types of airplanes for conditions of gusts, no gusts, and total landings.



Landing condition	Number of landings	
	Rolling in direction of first wheel	Rolling away from first wheel
Gusts	142	89
No gusts	114	68
Total	256	157

FIGURE 10.—Probability of equaling or exceeding rolling velocity for conditions of gusts, no gusts, and total landings in direction of first wheel to touch and away from first wheel to touch.

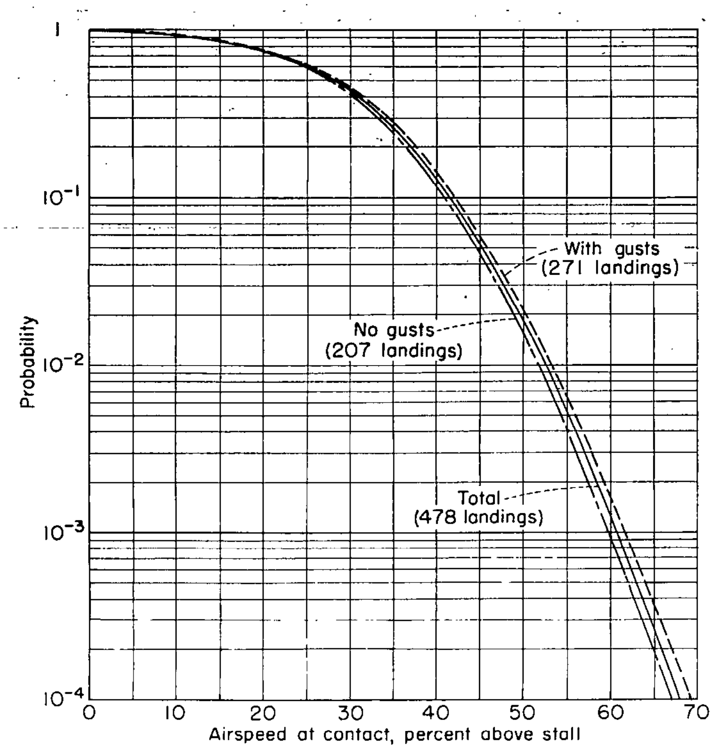


FIGURE 11.—Probability curve for percentage by which contact airspeed exceeds stalling speed. (Stalling speed for condition of 0.9 of maximum permissible landing weight.)

BANK ANGLE

The frequency distribution of bank angles at contact indicated a ratio of about 4 to 1 for the occurrence of landings with a left angle of bank (left wheel contacting first) compared to landings with an angle of bank to the right at contact. Two effects may have contributed to the predominance of left angles of bank: (1) the pilot's location on the left side of the airplane, which, according to the opinion of experienced pilots, results in a tendency to carry the left wing slightly low, and (2) a greater percentage of landings with cross winds from the left (left and right cross winds are in the ratio of about 10 to 1).

The curve for the probability of equaling or exceeding given angles of bank for the 413 airplane landings for which this quantity was obtained indicates that an angle of bank of 6° will probably be equaled or exceeded once in about 900 landings (fig. 8). For conditions without gusts, under which 182 observations were made, a bank angle of 6° would be expected to be equaled or exceeded once in only about 8,000 landings, whereas the curve for gusty conditions predicts a probability of a bank angle of 6° once in about 450 landings. Out of 1,000 landings, the values of bank angle likely to be equaled or exceeded once are 4.8° and 6.6° for conditions of no gusts and gusts, respectively. The limitation of roll angle imposed by some part of the airplane other than the landing gear contacting the ground first is from 8° to 16° for the four-engine transport airplanes and from 17° to 21° for the twin-engine transport airplanes considered in the present analysis. The probability curves of bank angle for the categories of twin-engine and four-engine airplanes, together with the effect of gusts (fig. 9), indicate that with the twin-engine airplanes there was a considerably higher probability of equaling or exceeding a given angle of bank than with the four-engine airplanes. For the total number of landings, for example, a bank angle of 5° is expected to be equaled or exceeded once in about 130 landings for the twin-engine airplanes, whereas a 5° angle of bank for the four-engine airplanes would be equaled or exceeded once in only about 1,000 landings. The effect of gusty-wind conditions, as before, is to increase the probability of equaling or exceeding a given angle of bank.

The difference in mean bank angles at contact and the difference in the standard deviations from these means between the 231 landings with gusts and the 182 landings without gusts (see table III(b) and fig. 8) are statistically significant. The differences in mean bank angles and the standard deviations from the means between the 242 landings of twin-engine transports and the 171 landings of four-engine airplanes (see table III(b) and fig. 9) are also statistically significant (see ref. 5).

ROLLING VELOCITY

The frequency distributions indicated about twice as many cases of airplanes rolling in the direction of the first wheel to touch as compared to those for airplanes rolling away from the first wheel to contact. The probability curves of rolling velocity (fig. 10) were computed by considering the group of rolling velocities in each direction as an entity. Then the ordinates of the curves for rolling both toward and away from the first wheel to touch were multiplied by 0.62 and 0.38, respectively (relative percentages of occurrence of the two events). (See fig. 10.)

The probability curves of rolling velocity indicate a greater probability of equaling or exceeding a given value for airplanes rolling in the direction of the first wheel to touch than for airplanes rolling away. The effect of the gust condition increased the probability of equaling or exceeding a given rolling velocity for rolling in either direction. For example, out of 1,000 landings, the values of rolling velocity likely to be equaled or exceeded once are 4.4 deg/sec and 5.3 deg/sec for conditions of no gusts and gusts, respectively. The differences in probabilities between the curves for the total number of landings for rolling in either direction decrease as rolling velocities increase above about 2 deg/sec. This result was also true for landings made under gusty conditions.

AIRSPEED AT CONTACT

The probability curves (fig. 11) for the percentage by which contact airspeed exceeds stalling speed indicate that 1 out of 10 transport airplanes in routine daytime operations will touch down with an airspeed which is equal to or greater than 40 percent above the stalling speed (based on an assumed loading of 0.9 of the maximum permissible landing weight). For 1 out of 100 landings, the contact airspeed will equal or exceed a speed 50 percent above the stalling speed, and for 1 out of 1,000 landings, the contact airspeed will equal or exceed a speed about 60 percent above the stalling speed. Gustiness appeared to have only a very small effect on the airspeed at contact, as contrasted to the relatively substantial effects on the probabilities of equaling or exceeding given values of sinking speed, bank angle, and rolling velocity, as has been pointed out previously. In this case, the reason for the absence of an effect due to gusts may be that the airplanes land so fast that there is sufficient speed margin above the stall to take care of the gusty conditions. The effect on the airspeed at contact due to various runway lengths cannot be indicated, insamuch as all the data so far obtained have been for landings made on only one runway.

The frequency distribution for the percentage of landing airspeed above stalling speed indicates that the greatest number of landings (201 out of the 478, or 42 percent) occurred in the range from 20 to 30 percent above the stalling speed, and the next largest number (142 or 30 percent) occurred in the range from 30 to 40 percent above the stalling speed. These facts are evidenced in figure 11 by the relatively high probabilities (above 0.1) indicated by the curve at all percentages up to 40 percent above the stalling speed.

CONCLUSIONS

Results of the analysis of the 478 landings obtained during clear-weather operations of present-day transport airplanes landing on a runway 5,210 feet long at the Washington National Airport have indicated the following conclusions:

1. For the transport airplanes in general, the gusty condition had a substantial effect in increasing the values of sinking speed, bank angle, and rolling velocity likely to be equaled or exceeded once for a given probability but had essentially no effect on the airspeeds at contact.

   (a) Out of 1,000 landings under conditions of no gusts, the values of sinking speed, bank angle, and rolling velocity (in the direction of the first wheel to touch) likely to be equaled or exceeded once are 3.5 ft/sec, 4.8°, or 4.4 deg/sec, respectively.

   (b) Out of 1,000 landings under conditions with gusts, the values of sinking speed, bank angle, and rolling velocity (in the direction of the first wheel to touch) likely to be equaled or exceeded once are 4.7 ft/sec, 6.6°, or 5.3 deg/sec, respectively.

   (c) The airplanes, in general, touched down at airspeeds with a considerable margin above the stall; the airspeed at contact in 1 out of 1,000 landings will probably equal or exceed an airspeed 60 percent above the stalling speed (based on an assumed loading of 0.9 of the maximum permissible landing weight).

2. Although wing loading was seen to have some effect on the sinking speeds of various transport airplanes, that is, there was a tendency for airplanes of higher wing loading to land with higher sinking speeds, the actual correspondence was rather poor, and study of a greater number of landings is required in order to analyze the influence of wing loading and other parameters which cause the differences in sinking speeds for the various types of airplanes.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., *March 17, 1954.*

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TABLE II

VALUES OF CONTACT CONDITIONS AND OTHER PERTINENT DATA FOR TRANSPORT LANDINGS

Landing number	Airplane type	Date of landing	Time of landing	Wind direction	Wind velocity, mph	Maximum gust velocity, mph	Parallel wind component, mph (a)	Cross-wind component, mph	Sinking speed, fps	Rolling velocity, deg/sec (b)	Bank angle, deg (c)	Forward ground speed, mph	Airspeed, mph
4	A	Jan. 14	1312	--------	Calm	--------	0	0	2.4	--------	------	84.0	84.0
6	B	Jan. 14	1340	--------	Calm	--------	0	0	1.0	−0.6	0.6	83.5	83.5
7	G	Jan. 14	1354	--------	Calm	--------	0	0	1.2	--------	------	109.3	109.3
8	A	Jan. 14	1400	S	2	--------	−1.7	1.0	1.3	1.6	0	93.9	92.2
9	E	Jan. 14	1408	S	2	--------	−1.7	1.0	.9	.6	−.9	100.5	98.8
11	E	Jan. 15	0934	SSE	3	--------	−3.0	.4	1.3	.4	−1.0	102.1	99.1
13	A	Jan. 15	0942	SSE	3	--------	−3.0	.4	.9	1.9	.3	101.1	98.1
14	G	Jan. 15	0953	SSE	3	--------	−3.0	.4	1.0	.4	−2.7	112.2	109.2
15	B	Jan. 15	0955	SSE	3	--------	−3.0	.4	.9	--------	------	87.4	84.4
16	A	Jan. 15	1000	SSE	3	--------	−3.0	.4	.2	−.7	−.6	92.6	89.6
17	G	Jan. 15	1005	S	6	--------	−5.2	3.0	.8	−.2	−1.7	107.5	102.3
19	B	Jan. 15	1010	S	6	--------	−5.2	3.0	.1	.1	0	75.9	70.7
20	A	Jan. 16	1425	WNW	16	24	12.6	9.8	.4	2.7	−2.7	72.4	85.0
21	F	Jan. 16	1427	WNW	16	24	12.6	9.8	1.4	−.4	−1.3	85.9	98.5
22	G	Jan. 16	1431	WNW	16	24	12.6	9.8	2.6	--------	------	101.1	113.7
23	B	Jan. 16	1432	WNW	16	24	12.6	9.8	.9	--------	------	60.9	73.5
24	G	Jan. 16	1433	WNW	16	24	12.6	9.8	1.8	−.8	−5.5	99.0	111.6
25	F	Jan. 16	1438	WNW	16	24	12.6	9.8	.4	−.9	−.9	93.0	105.6
26	A	Jan. 16	1440	WNW	16	24	12.6	9.8	.8	1.7	1.5	102.5	115.1
27	E	Jan. 16	1441	WNW	16	24	12.6	9.8	1.5	−.6	−1.7	94.8	107.4
28	E	Jan. 16	1446	WNW	16	24	12.6	9.8	2.0	1.5	−.6	90.2	102.8
29	E	Jan. 16	1452	WNW	16	24	12.6	9.8	2.5	1.3	−1.8	91.9	104.5
30	G	Jan. 16	1455	WNW	16	24	12.6	9.8	1.0	--------	------	94.3	106.9
31	E	Jan. 16	1456	WNW	16	24	12.6	9.8	2.0	.1	−1.4	96.8	109.4
32	B	Jan. 16	1500	NW	12	20	11.6	3.1	1.8	--------	------	72.6	84.2
34	E	Jan. 16	1514	NW	12	20	11.6	3.1	3.0	2.6	1.2	84.3	95.9
35	G	Jan. 16	1515	NW	12	20	11.6	3.1	.9	1.3	−1.1	99.4	111.0
43	F	Jan. 26	1105	NW	16	24	15.5	4.1	1.2	--------	------	93.6	109.1
45	J	Jan. 26	1111	NW	16	24	15.5	4.1	.6	−.5	−1.2	91.7	107.2
46	F	Jan. 26	1127	NW	16	24	15.5	4.1	1.7	−.8	2.0	75.8	91.3
47	J	Jan. 26	1130	NW	16	24	15.5	4.1	1.2	−.8	−.8	95.7	111.2
49	G	Jan. 26	1145	NW	16	24	15.5	4.1	1.4	2.0	.6	93.9	109.4
50	G	Jan. 26	1150	NW	16	24	15.5	4.1	1.0	.6	−1.1	98.1	113.6
51	E	Jan. 26	1200	NNW	16	--------	15.8	2.2	1.4	--------	------	84.9	100.7
52	E	Jan. 26	1201	NNW	16	--------	15.8	2.2	1.1	--------	------	85.1	100.9
53	J	Jan. 26	1202	NNW	16	--------	15.8	2.2	1.3	−.2	−.6	88.9	104.7
54	G	Jan. 26	1203	NNW	16	--------	15.8	2.2	1.1	.8	−.6	104.9	120.7
55	E	Jan. 26	1205	NNW	16	--------	15.8	2.2	1.3	2.6	−.1	88.1	103.9
56	H	Jan. 26	1209	NNW	16	--------	15.8	2.2	2.0	1.2	−1.4	78.2	94.0
57	E	Jan. 26	1211	NNW	16	--------	15.8	2.2	1.0	.6	−.2	81.1	96.9
58	F	Jan. 26	1213	NNW	16	--------	15.8	2.2	1.0	−1.1	−.2	75.8	91.6
59	H	Jan. 26	1215	NNW	16	--------	15.8	2.2	1.6	1.0	−1.7	91.5	107.3
60	E	Jan. 26	1216	NNW	16	--------	15.8	2.2	1.7	−1.0	−1.4	72.8	88.6
61	E	Jan. 26	1217	NNW	16	--------	15.8	2.2	.6	−.8	1.4	82.9	98.7
62	H	Jan. 26	1220	NNW	16	--------	15.8	2.2	2.4	.3	−.3	89.2	105.0
64	F	Jan. 26	1250	NW	15	--------	14.5	3.9	.3	.4	.5	82.1	96.6
65	A	Jan. 26	1251	NW	15	--------	14.5	3.9	1.8	1.0	0	79.6	94.1
69	J	Jan. 26	1305	NW	15	--------	14.5	3.9	.9	−1.7	−.5	99.5	114.0
70	G	Jan. 26	1308	NW	15	--------	14.5	3.9	1.1	0	1.0	95.9	110.4
72	H	Jan. 26	1337	NW	15	--------	14.5	3.9	.5	--------	------	92.7	107.2
74	E	Jan. 26	1346	NW	15	--------	14.5	3.9	.8	−.9	−.2	87.2	101.7
77	A	Jan. 26	1406	NW	17	--------	16.4	4.4	.9	1.5	.2	83.5	99.9
80	G	Jan. 26	1423	NW	17	--------	16.4	4.4	.6	−2.2	−.7	99.1	115.5
81	G	Jan. 26	1427	NW	17	--------	16.4	4.4	1.7	−.5	.3	104.1	120.5
82	B	Jan. 26	1428	NW	17	--------	16.4	4.4	.8	−1.2	.7	78.3	94.7
83	E	Jan. 26	1431	NW	17	--------	16.4	4.4	1.6	--------	------	80.9	97.3
85	E	Jan. 26	1440	NW	17	--------	16.4	4.4	.9	−.1	−.4	83.3	99.7
94	G	Feb. 9	1115	WNW	14	23	11.0	8.6	2.0	−1.0	.4	91.7	102.7
95	J	Feb. 9	1120	WNW	14	23	11.0	8.6	2.7	.1	.3	100.6	111.6
97	J	Feb. 9	1134	WNW	14	23	11.0	8.6	.1	1.4	−.3	105.5	116.5
98	D	Feb. 9	1140	WNW	14	23	11.0	8.6	.4	2.5	−1.7	91.5	102.5
99	B	Feb. 9	1142	WNW	14	23	11.0	8.6	1.0	--------	------	81.2	92.2
100	G	Feb. 9	1152	WNW	14	23	11.0	8.6	3.1	--------	------	101.8	112.8
101	J	Feb. 9	1157	WNW	14	23	11.0	8.6	1.9	−.6	−.1	98.8	109.8
102	J	Feb. 9	1158	WNW	14	23	11.0	8.6	2.0	.3	−1.7	102.5	113.5
104	J	Feb. 9	1203	W	16	25	8.0	13.8	2.3	--------	------	88.1	96.1
107	B	Feb. 9	1212	W	16	25	8.0	13.8	1.8	−.2	−2.7	73.7	81.7
109	H	Feb. 9	1215	W	16	25	8.0	13.8	1.7	−.1	−1.2	92.6	100.6
110	G	Feb. 9	1216	W	16	25	8.0	13.8	.8	.6	−2.5	93.0	101.0
111	B	Feb. 9	1218	W	16	25	8.0	13.8	1.1	0	−3.5	70.2	78.2

a Positive values—head wind.
b Positive values—rolling in direction of first wheel to touch.
c Positive values—right bank.

TABLE II—Continued

VALUES OF CONTACT CONDITIONS AND OTHER PERTINENT DATA FOR TRANSPORT LANDINGS

Landing number	Airplane type	Date of landing	Time of landing	Wind direction	Wind velocity, mph	Maximum gust velocity, mph	Parallel wind component, mph (a)	Cross-wind component, mph	Sinking speed, fps	Rolling velocity, deg/sec (b)	Bank angle, deg (c)	Forward ground speed, mph	Airspeed, mph
112	B	Feb. 9	1233	W	16	25	8.0	13.8	1.0	−2.1	−1.1	72.3	80.3
115	E	Feb. 9	1245	W	16	25	8.0	13.8	1.6	.4	−.2	82.3	90.3
116	G	Feb. 9	1250	W	16	25	8.0	13.8	1.3	--------	------	95.6	103.6
120	G	Feb. 9	1306	WNW	15	24	11.8	9.2	2.3	1.3	−1.2	90.2	102.0
121	G	Feb. 9	1315	WNW	15	24	11.8	9.2	1.4	1.5	−2.0	97.7	109.5
122	J	Feb. 9	1318	WNW	15	24	11.8	9.2	2.1	.3	−2.3	103.8	115.6
123	B	Feb. 9	1335	WNW	15	24	11.8	9.2	.9	1.3	−3.0	67.0	78.8
124	G	Feb. 9	1350	WNW	15	24	11.8	9.2	1.0	−1.2	−.8	106.1	117.9
130	J	Feb. 9	1405	WNW	16	25	12.6	9.9	1.8	.5	−1.4	77.4	90.0
132	G	Feb. 9	1408	WNW	16	25	12.6	9.9	1.6	2.3	−3.2	84.3	96.9
134	E	Feb. 9	1411	WNW	16	25	12.6	9.9	2.1	−.7	.1	78.0	90.6
135	G	Feb. 9	1416	WNW	16	25	12.6	9.9	1.3	2.2	−1.8	99.5	112.1
137	E	Feb. 9	1431	WNW	16	25	12.6	9.9	.4	−.3	−3.3	86.4	99.0
138	I	Feb. 9	1432	WNW	16	25	12.6	9.9	1.8	2.8	−1.1	101.3	113.9
140	G	Feb. 9	1441	WNW	16	25	12.6	9.9	2.0	.9	−.4	85.9	98.5
141	J	Feb. 9	1443	WNW	16	25	12.6	9.9	1.3	1.9	.7	78.8	91.4
142	B	Feb. 10	1055	NW	14	--------	13.5	3.6	1.3	1.5	−.3	86.2	99.7
144	E	Feb. 10	1058	NW	14	--------	13.5	3.6	.6	--------	------	89.8	103.3
145	E	Feb. 10	1100	NW	15	--------	14.5	3.9	.4	1.2	−.1	82.8	97.3
148	F	Feb. 10	1106	NW	15	--------	14.5	3.9	1.4	1.2	−1.1	86.2	100.7
149	F	Feb. 10	1111	NW	15	--------	14.5	3.9	.6	−1.1	.5	81.3	95.8
150	B	Feb. 10	1113	NW	15	--------	14.5	3.9	.4	2.8	−.6	71.4	85.9
151	J	Feb. 10	1121	NW	15	--------	14.5	3.9	1.9	--------	------	90.4	104.9
153	B	Feb. 10	1145	NW	15	--------	14.5	3.9	1.0	0	.9	76.5	91.0
154	G	Feb. 10	1150	NW	15	--------	14.5	3.9	1.5	--------	------	101.1	115.6
157	E	Feb. 10	1200	NNW	16	--------	15.8	2.2	.6	1.5	.4	76.5	92.3
158	E	Feb. 10	1201	NNW	16	--------	15.8	2.2	2.4	.3	.6	8 .6	96.4
159	H	Feb. 10	1205	NNW	16	--------	15.8	2.2	1.8	1.9	−.8	89.8	105.6
162	J	Feb. 10	1210	NNW	16	--------	15.8	2.2	1.4	--------	------	97.5	113.3
163	E	Feb. 10	1213	NNW	16	--------	15.8	2.2	1.8	−.2	−1.6	88.3	104.1
164	B	Feb. 10	1215	NNW	16	--------	15.8	2.2	.7	2.3	−1.4	67.6	83.4
167	H	Feb. 10	1233	NNW	16	--------	15.8	2.2	1.8	--------	------	87.9	103.7
168	G	Feb. 10	1236	NNW	16	--------	15.8	2.2	1.5	−.6	−1.6	83.8	99.6
169	J	Feb. 10	1255	NNW	16	--------	15.8	2.2	1.0	1.9	−.9	99.2	115.0
170	G	Feb. 10	1301	NW	17	--------	16.4	4.4	1.2	.1	−.3	89.6	106.0
171	B	Feb. 10	1303	NW	17	--------	16.4	4.4	.8	2.1	1.5	76.2	92.6
172	G	Feb. 10	1310	NW	17	--------	16.4	4.4	2.3	−1.6	−.3	96.0	112.4
173	K	Feb. 10	1325	NW	17	--------	16.4	4.4	.7	.8	−1.3	98.1	114.5
174	J	Feb. 10	1327	NW	17	--------	16.4	4.4	1.1	2.3	−.6	100.0	116.4
175	B	Feb. 10	1328	NW	17	--------	16.4	4.4	1.0	1.3	.1	78.2	94.6
176	B	Feb. 10	1332	NW	17	--------	16.4	4.4	.5	.9	−1.3	68.4	84.8
178	G	Feb. 10	1341	NW	17	--------	16.4	4.4	.7	--------	------	91.0	107.4
180	F	Feb. 10	1346	NW	17	--------	16.4	4.4	.4	--------	------	81.1	97.5
181	B	Feb. 10	1347	NW	17	--------	16.4	4.4	1.9	−.5	−1.0	80.0	96.4
184	G	Feb. 10	1403	WNW	17	--------	13.4	10.5	.2	--------	------	93.3	106.7
185	I	Feb. 10	1406	WNW	17	--------	13.4	10.5	1.2	−1.8	.2	104.2	117.6
186	F	Feb. 10	1409	WNW	17	--------	13.4	10.5	1.1	−.3	−1.4	76.3	89.7
187	B	Feb. 10	1410	WNW	17	--------	13.4	10.5	.3	1.9	−.6	77.8	91.2
188	E	Feb. 10	1411	WNW	17	--------	13.4	10.5	1.2	--------	------	84.4	97.8
189	F	Feb. 10	1416	WNW	17	--------	13.4	10.5	1.2	.6	−.1	91.9	105.3
190	A	Feb. 10	1419	WNW	17	--------	13.4	10.5	1.2	1.2	1.4	65.5	78.9
191	F	Feb. 10	1422	WNW	17	--------	13.4	10.5	1.6	.2	−1.0	78.8	92.2
194	G	Feb. 10	1438	WNW	17	--------	13.4	10.5	1.9	.8	−2.9	88.9	102.3
195	D	Feb. 10	1441	WNW	17	--------	13.4	10.5	1.0	2.5	1.6	87.9	101.3
196	F	Feb. 10	1442	WNW	17	--------	13.4	10.5	1.7	.4	−.1	83.1	96.5
198	E	Feb. 10	1447	WNW	17	--------	13.4	10.5	2.0	−.1	−.6	81.2	94.6
199	H	Mar. 5	1036	WSW	16	24	2.2	15.8	2.5	2.6	3.9	101.8	104.0
200	B	Mar. 5	1040	WSW	16	24	2.2	15.8	.3	1.7	.4	78.8	81.0
201	J	Mar. 5	1055	WSW	16	24	2.2	15.8	1.8	−.2	.4	108.2	110.4
202	J	Mar. 5	1057	WSW	16	24	2.2	15.8	2.5	--------	------	108.2	110.4
203	E	Mar. 5	1102	WNW	22	33	17.3	13.6	1.0	.6	−3.0	96.4	113.7
205	J	Mar. 5	1115	WNW	22	33	17.3	13.6	1.1	.6	−.8	95.1	112.4
206	F	Mar. 5	1116	WNW	22	33	17.3	13.6	1.2	--------	------	84.4	101.7
207	B	Mar. 5	1120	WNW	22	33	17.3	13.6	.8	−.1	.4	82.9	100.2
208	G	Mar. 5	1123	WNW	22	33	17.3	13.6	1.4	--------	------	96.5	113.8
211	H	Mar. 5	1154	WNW	22	33	17.3	13.6	.5	−.2	−.6	101.7	119.0
212	F	Mar. 5	1156	WNW	22	33	17.3	13.6	.1	.9	−.4	83.5	100.8
213	G	Mar. 5	1158	WNW	22	33	17.3	13.6	1.5	.4	−.3	99.9	117.2
214	H	Mar. 5	1201	WNW	18	30	14.2	11.1	.6	2.7	−2.0	89.4	103.6
215	J	Mar. 5	1206	WNW	18	30	14.2	11.1	1.3	.1	−2.3	98.5	112.7

a Positive values—head wind.
b Positive values—rolling in direction of first wheel to touch.
c Positive values—right bank.

TABLE II—Continued

VALUES OF CONTACT CONDITIONS AND OTHER PERTINENT DATA FOR TRANSPORT LANDINGS

Landing number	Airplane type	Date of landing	Time of landing	Wind direction	Wind velocity, mph	Maximum gust velocity, mph	Parallel wind component, mph (a)	Cross-wind component, mph	Sinking speed, fps	Rolling velocity, deg/sec (b)	Bank angle, deg (c)	Forward ground speed, mph	Airspeed, mph
217	H	Mar. 5	1209	WNW	18	30	14.2	11.1	2.3	−2.0	−.3	81.8	96.0
218	E	Mar. 5	1212	WNW	18	30	14.2	11.1	1.1	1.8	−1.1	86.2	100.4
219	F	Mar. 5	1216	WNW	18	30	14.2	11.1	1.6	−.4	.1	92.0	106.2
220	E	Mar. 5	1219	WNW	18	30	14.2	11.1	1.8	.1	−.6	83.1	97.3
222	H	Mar. 5	1223	WNW	18	30	14.2	11.1	1.3	--------	------	95.1	109.3
224	G	Mar. 5	1229	WNW	18	30	14.2	11.1	1.9	--------	------	94.0	108.2
225	E	Mar. 5	1230	WNW	18	30	14.2	11.1	3.6	1.1	−2.1	81.6	95.8
226	E	Mar. 5	1238	WNW	18	30	14.2	11.1	2.5	1.9	−2.5	89.0	103.2
229	J	Mar. 5	1250	WNW	18	30	14.2	11.1	1.7	.6	−2.3	94.6	108.8
231	H	Mar. 5	1259	WNW	18	30	14.2	11.1	1.9	.9	−1.8	98.3	112.5
232	G	Mar. 5	1304	WNW	22	36	17.3	13.6	1.9	1.0	−3.4	89.3	106.6
233	J	Mar. 5	1327	WNW	22	36	17.3	13.6	2.2	--------	------	92.3	109.6
234	J	Mar. 5	1407	WNW	22	34	17.3	13.6	1.8	1.7	−3.6	90.7	108.0
235	E	Mar. 5	1408	WNW	22	34	17.3	13.6	1.4	1.8	−3.8	94.0	111.3
236	F	Mar. 5	1420	WNW	22	34	17.3	13.6	1.2	--------	------	86.2	103.5
239	E	Mar. 5	1427	WNW	22	34	17.3	13.6	.9	−.1	.4	78.4	95.7
240	F	Mar. 5	1435	WNW	22	34	17.3	13.6	1.1	.4	−1.7	82.6	99.9
241	G	Mar. 5	1436	WNW	22	34	17.3	13.6	2.4	--------	------	87.1	104.4
242	C	Mar. 5	1438	WNW	22	34	17.3	13.6	.7	3.6	−1.9	80.8	98.1
243	F	Mar. 5	1439	WNW	22	34	17.3	13.6	2.4	.1	1.1	79.3	96.6
245	F	Mar. 5	1446	WNW	22	34	17.3	13.6	1.9	.3	−2.1	79.1	96.4
246	E	Mar. 5	1458	WNW	22	34	17.3	13.6	.7	−1.5	−2.3	88.6	105.9
247	I	Mar. 5	1459	WNW	22	34	17.3	13.6	1.8	.2	−3.3	99.9	117.2
248	G	Mar. 5	1500	WNW	22	34	17.3	13.6	1.9	−2.6	−3.7	98.2	115.5
252	G	Mar. 9	1105	NW	15	--------	14.5	3.9	1.9	.8	.7	100.1	114.6
253	F	Mar. 9	1109	NW	15	--------	14.5	3.9	.5	−.3	−.9	82.3	96.8
254	J	Mar. 9	1113	NW	15	--------	14.5	3.9	2.3	.5	−.2	107.9	122.4
255	F	Mar. 9	1116	NW	15	--------	14.5	3.9	1.6	.7	.1	86.6	101.1
256	J	Mar. 9	1118	NW	15	--------	14.5	3.9	.6	−.5	−.5	99.4	113.9
259	J	Mar. 9	1133	NW	15	--------	14.5	3.9	1.8	1.0	−1.3	101.6	116.1
261	G	Mar. 9	1148	NW	15	--------	14.5	3.9	.8	−1.9	.2	91.4	105.9
263	J	Mar. 9	1200	W	12	--------	6.0	10.4	2.1	.7	−.2	108.1	114.1
264	E	Mar. 9	1201	W	12	--------	6.0	10.4	1.9	1.3	1.0	86.8	92.8
265	E	Mar. 9	1202	W	12	--------	6.0	10.4	3.4	.1	−3.2	91.8	97.8
266	J	Mar. 9	1207	W	12	--------	6.0	10.4	2.5	−.2	.2	95.0	101.0
267	F	Mar. 9	1208	W	12	--------	6.0	10.4	1.3	−.2	−.5	95.8	101.8
268	E	Mar. 9	1211	W	12	--------	6.0	10.4	.6	0	−1.3	80.3	86.3
270	H	Mar. 9	1216	W	12	--------	6.0	10.4	1.1	−1.8	−1.2	89.7	95.7
271	H	Mar. 9	1221	W	12	--------	6.0	10.4	.5	1.1	−.4	96.9	102.9
272	J	Mar. 9	1231	W	12	--------	6.0	10.4	1.5	--------	------	101.4	107.4
273	H	Mar. 9	1234	W	12	--------	6.0	10.4	1.8	1.1	−1.4	106.4	112.4
274	J	Mar. 9	1237	W	12	--------	6.0	10.4	.5	−.6	−1.4	112.1	118.1
275	F	Mar. 9	1238	W	12	--------	6.0	10.4	1.3	.3	−1.2	90.9	96.9
276	G	Mar. 9	1240	W	12	--------	6.0	10.4	1.9	.9	−3.7	110.4	116.4
278	H	Mar. 9	1250	W	12	--------	6.0	10.4	1.8	.4	−1.1	100.5	106.5
280	B	Mar. 9	1303	W	10	--------	5.0	8.7	1.4	--------	------	75.4	80.4
281	G	Mar. 9	1310	W	10	--------	5.0	8.7	1.6	.4	−.4	106.4	111.4
282	E	Mar. 9	1326	W	10	--------	5.0	8.7	2.4	2.3	−1.1	84.4	89.4
283	A	Mar. 9	1329	W	10	--------	5.0	8.7	1.5	1.5	−1.4	86.0	91.0
284	E	Mar. 9	1339	W	10	--------	5.0	8.7	1.1	.4	.8	87.1	92.1
285	B	Mar. 9	1347	W	10	--------	5.0	8.7	.8	3.5	−.8	71.2	76.2
286	F	Mar. 9	1350	W	10	--------	5.0	8.7	1.2	−.5	−1.8	92.6	97.2
288	G	Mar. 9	1357	W	10	--------	5.0	8.7	.6	−1.2	−.1	93.7	98.7
289	F	Mar. 9	1401	WNW	8	--------	6.3	4.9	1.3	.1	−1.3	85.8	92.1
290	G	Mar. 9	1403	WNW	8	--------	6.3	4.9	.8	−2.0	−1.2	90.0	96.3
291	I	Mar. 9	1404	WNW	8	--------	6.3	4.9	.8	.5	−1.9	102.0	108.3
292	E	Mar. 9	1405	WNW	8	--------	6.3	4.9	2.2	3.2	−3.2	90.2	96.5
294	F	Mar. 9	1410	WNW	8	--------	6.3	4.9	1.9	1.8	−1.7	91.5	97.8
295	A	Mar. 9	1413	WNW	8	--------	6.3	4.9	.4	0	−1.0	90.9	97.2
296	B	Mar. 9	1419	WNW	8	--------	6.3	4.9	1.0	−.4	−.2	69.5	75.8
297	F	Mar. 9	1422	WNW	8	--------	6.3	4.9	1.2	1.2	−1.0	83.0	89.3
298	G	Mar. 9	1431	WNW	8	--------	6.3	4.9	1.7	.9	−2.2	106.0	112.3
299	B	Mar. 19	1126	WNW	20	26	15.8	12.3	1.1	--------	------	87.3	103.1
300	H	Mar. 19	1129	WNW	20	26	15.8	12.3	.6	3.5	1.5	97.7	113.5
301	E	Mar. 19	1130	WNW	20	26	15.8	12.3	1.0	.2	−2.6	82.8	98.6
302	G	Mar. 19	1140	WNW	20	26	15.8	12.3	.5	.6	−1.4	89.0	104.8
304	E	Mar. 19	1152	WNW	20	26	15.8	12.3	2.9	−.1	−.5	79.3	95.1
305	B	Mar. 19	1156	WNW	20	26	15.8	12.3	1.9	−1.3	−2.7	80.0	95.8
306	G	Mar. 19	1200	NW	18	25	17.4	4.7	2.4	.6	−2.9	111.0	128.4
307	J	Mar. 19	1202	NW	18	25	17.4	4.7	1.9	.4	0	102.4	119.8

[a] Positive values—head wind.
[b] Positive values—rolling in direction of first wheel to touch.
[c] Positive values—right bank.

TABLE II—Continued

VALUES OF CONTACT CONDITIONS AND OTHER PERTINENT DATA FOR TRANSPORT LANDINGS

Landing number	Airplane type	Date of landing	Time of landing	Wind direction	Wind velocity, mph	Maximum gust velocity, mph	Parallel wind component, mph (a)	Cross-wind component, mph	Sinking speed, fps	Rolling velocity, deg/sec (b)	Bank angle, deg (c)	Forward ground speed, mph	Airspeed, mph
308	F	Mar. 19	1205	NW	18	25	17.4	4.7	1.9	----------	----------	72.4	89.8
309	B	Mar. 19	1212	NW	18	25	17.4	4.7	1.0	−1.6	−4	71.0	88.4
310	E	Mar. 19	1214	NW	18	25	17.4	4.7	1.6	−1.7	−.2	83.6	101.0
311	H	Mar. 19	1222	NW	18	25	17.4	4.7	1.8	2.0	−1.4	93.1	110.5
313	E	Mar. 19	1226	NW	18	25	17.4	4.7	.7	2.4	−1.7	92.2	109.6
314	J	Mar. 19	1227	NW	18	25	17.4	4.7	1.4	.1	−.5	108.1	125.5
315	J	Mar. 19	1231	NW	18	25	17.4	4.7	2.9	.4	0	91.3	108.7
316	E	Mar. 19	1234	NW	18	25	17.4	4.7	1.8	1.6	−1.6	83.6	101.0
317	J	Mar. 19	1241	NW	18	25	17.4	4.7	.8	.6	−.6	109.2	126.6
318	A	Mar. 19	1244	NW	18	25	17.4	4.7	.8	−2.2	−.5	76.1	93.5
319	E	Mar. 19	1246	NW	18	25	17.4	4.7	2.2	.8	−.3	91.9	109.3
320	H	Mar. 19	1247	NW	18	25	17.4	4.7	1.4	−1.6	−.6	98.2	115.6
321	H	Mar. 19	1250	NW	18	25	17.4	4.7	1.5	−.4	−.3	96.9	114.3
322	G	Mar. 19	1302	WNW	18	28	14.2	11.1	1.4	.7	−.1	94.5	108.7
323	G	Mar. 19	1304	WNW	18	28	14.2	11.1	2.2	.3	1.9	106.7	120.9
324	G	Mar. 19	1315	WNW	18	28	14.2	11.1	1.1	3.6	−.8	102.2	116.4
326	B	Mar. 19	1343	WNW	18	28	14.2	11.1	.9	1.6	−1.3	85.2	99.4
327	E	Mar. 19	1345	WNW	18	28	14.2	11.1	1.7	----------	----------	84.4	98.6
328	B	Mar. 19	1346	WNW	18	28	14.2	11.1	.9	1.3	−1.9	77.6	91.8
329	F	Mar. 19	1402	NW	15	----------	14.5	3.9	.4	1.4	1.2	98.8	113.3
331	G	Mar. 19	1409	NW	15	----------	14.5	3.9	.9	0	−1.4	100.9	115.4
332	I	Mar. 19	1410	NW	15	----------	14.5	3.9	2.4	−1.9	.6	109.3	123.8
333	J	Mar. 19	1411	NW	15	----------	14.5	3.9	.4	.3	.4	105.4	119.9
335	H	Mar. 19	1414	NW	15	----------	14.5	3.9	1.6	−1.2	.1	76.8	91.3
336	F	Mar. 19	1417	NW	15	----------	14.5	3.9	1.4	2.1	−1.8	89.4	103.9
337	G	Mar. 19	1418	NW	15	----------	14.5	3.9	1.6	−.4	−.1	105.8	120.3
338	G	Mar. 19	1422	NW	15	----------	14.5	3.9	1.4	−.6	−2.1	109.6	124.1
339	F	Mar. 19	1425	NW	15	----------	14.5	3.9	1.0	.8	.4	95.6	110.1
340	B	Mar. 19	1426	NW	15	----------	14.5	3.9	.9	2.6	−2.8	77.6	92.1
341	G	Mar. 19	1427	NW	15	----------	14.5	3.9	1.4	−.6	−2.1	116.4	130.9
342	E	Mar. 19	1428	NW	15	----------	14.5	3.9	2.1	−3.1	−.9	83.1	97.6
343	E	Mar. 19	1429	NW	15	----------	14.5	3.9	1.8	−1.6	−1.5	96.9	111.4
344	F	Mar. 19	1431	NW	15	----------	14.5	3.9	3.0	.2	−.9	100.0	114.5
346	F	Mar. 19	1440	NW	15	----------	14.5	3.9	1.4	1.0	−.9	101.4	115.9
347	G	Mar. 19	1442	NW	15	----------	14.5	3.9	.8	.9	−1.5	104.6	119.1
348	G	Mar. 19	1447	NW	15	----------	14.5	3.9	2.0	−1.9	−1.5	99.3	113.8
349	B	Mar. 19	1451	NW	15	----------	14.5	3.9	1.5	2.5	−2.3	81.0	95.5
350	G	Mar. 19	1452	NW	15	----------	14.5	3.9	1.9	1.5	−3.3	105.3	119.8
352	G	Mar. 20	1150	NW	18	28	17.4	4.7	2.3	−1.0	1.0	96.8	114.2
353	F	Mar. 20	1155	NW	18	28	17.4	4.7	1.2	0	.1	92.6	110.0
354	J	Mar. 20	1200	WNW	20	27	15.8	12.3	1.1	−.2	1.6	94.8	110.6
355	E	Mar. 20	1204	WNW	20	27	15.8	12.3	1.7	2.1	−2.8	86.7	102.5
357	B	Mar. 20	1213	WNW	20	27	15.8	12.3	1.1	1.6	.4	72.2	88.0
359	E	Mar. 20	1220	WNW	20	27	15.8	12.3	2.3	2.8	−2.1	86.8	102.6
360	H	Mar. 20	1221	WNW	20	27	15.8	12.3	2.6	−2.7	.6	88.6	104.4
361	F	Mar. 20	1222	WNW	20	27	15.8	12.3	3.1	−.9	−.9	80.6	96.4
363	J	Mar. 20	1226	WNW	20	27	15.8	12.3	2.0	2.3	−1.1	105.9	121.7
364	E	Mar. 20	1228	WNW	20	27	15.8	12.3	1.7	−2.4	−.2	70.8	86.6
365	G	Mar. 20	1230	WNW	20	27	15.8	12.3	1.1	−1.4	−1.5	96.1	111.9
368	J	Mar. 20	1242	WNW	20	27	15.8	12.3	.8	0	−.6	103.3	119.1
369	H	Mar. 20	1244	WNW	20	27	15.8	12.3	4.5	.4	−.9	98.0	113.8
370	G	Mar. 20	1250	WNW	20	27	15.8	12.3	.9	−1.2	−.9	102.5	118.3
372	G	Mar. 20	1310	NNW	15	22	14.8	2.1	1.1	0	1.4	95.8	110.6
373	G	Mar. 20	1312	NNW	15	22	14.8	2.1	1.0	1.4	.3	96.5	111.3
375	E	Mar. 20	1349	NNW	15	22	14.8	2.1	.8	−.6	−.1	86.6	101.4
376	J	Mar. 20	1353	NNW	15	22	14.8	2.1	1.4	.1	−1.2	98.8	113.6
377	G	Mar. 20	1356	NNW	15	22	14.8	2.1	.5	2.0	2.3	95.0	109.8
378	G	Mar. 20	1402	WNW	16	20	12.6	9.9	1.2	−1.1	−2.4	96.1	108.7
379	F	Mar. 20	1404	WNW	16	20	12.6	9.9	2.3	.2	−.1	87.5	100.1
381	E	Mar. 27	1103	WNW	20	28	15.8	12.3	2.8	1.5	−1.3	82.4	98.2
382	B	Mar. 27	1104	WNW	20	28	15.8	12.3	1.0	2.0	.2	79.8	95.6
383	B	Mar. 27	1111	WNW	20	28	15.8	12.3	1.1	−.1	−3.3	87.5	103.3
384	F	Mar. 27	1124	WNW	20	28	15.8	12.3	2.3	−1.1	−.6	100.7	116.5
386	B	Mar. 27	1130	WNW	20	28	15.8	12.3	1.6	.5	−2.0	70.8	86.6
387	J	Mar. 27	1139	WNW	20	28	15.8	12.3	.1	−.1	−1.6	97.8	113.6
388	J	Mar. 27	1143	WNW	20	28	15.8	12.3	1.7	2.5	−.6	92.7	108.5
389	G	Mar. 27	1151	WNW	20	28	15.8	12.3	2.5	−.1	−.8	99.2	115.0
390	F	Mar. 27	1156	WNW	20	28	15.8	12.3	1.5	−.5	−.5	94.1	109.9
391	E	Mar. 27	1200	WNW	14	29	11.0	8.6	1.0	.3	−.2	93.9	104.9
392	F	Mar. 27	1202	WNW	14	29	11.0	8.6	1.6	.6	−1.7	83.2	94.2

[a] Positive values—head wind.
[b] Positive values—rolling in direction of first wheel to touch.
[c] Positive values—right bank.

TABLE II—Continued

VALUES OF CONTACT CONDITIONS AND OTHER PERTINENT DATA FOR TRANSPORT LANDINGS

Landing number	Airplane type	Date of landing	Time of landing	Wind direction	Wind velocity, mph	Maximum gust velocity, mph	Parallel wind component, mph [a]	Cross-wind component, mph	Sinking speed, fps	Rolling velocity, deg/sec [b]	Bank angle, deg [c]	Forward ground speed, mph	Airspeed, mph
393	E	Mar. 27	1211	WNW	14	29	11.0	8.6	1.7	0.4	−0.8	83.6	94.6
394	B	Mar. 27	1217	WNW	14	29	11.0	8.6	.4	−2.1	−1.3	72.1	83.1
395	F	Mar. 27	1218	WNW	14	29	11.0	8.6	2.2	.1	−1.4	88.0	99.0
396	E	Mar. 27	1225	WNW	14	29	11.0	8.6	2.7	−.1	−.8	81.8	92.8
397	H	Mar. 27	1226	WNW	14	29	11.0	8.6	.3	1.6	−1.8	94.7	105.7
398	E	Mar. 27	1227	WNW	14	29	11.0	8.6	.3	−.9	−1.1	94.3	105.3
399	J	Mar. 27	1229	WNW	14	29	11.0	8.6	1.2	.4	−.5	105.0	116.0
400	J	Mar. 27	1230	WNW	14	29	11.0	8.6	2.0	−1.3	.3	99.2	110.0
401	J	Mar. 27	1231	WNW	14	29	11.0	8.6	1.6	−.4	−2.2	107.6	118.6
402	E	Mar. 27	1233	WNW	14	29	11.0	8.6	1.3	−.3	−1.6	93.4	104.4
403	H	Mar. 27	1238	WNW	14	29	11.0	8.6	1.3	−.4	−1.4	101.8	112.8
404	H	Mar. 27	1246	WNW	14	29	11.0	8.6	1.2	−.4	−.8	93.5	104.5
406	G	Mar. 27	1315	WNW	16	--------	12.6	9.9	.8	1.5	−2.6	95.8	108.4
407	G	Mar. 27	1336	WNW	16	--------	12.6	9.9	1.2	.1	−2.1	104.0	116.6
409	F	Mar. 27	1343	WNW	16	--------	12.6	9.9	2.0	.1	−.9	96.0	108.6
410	B	Mar. 27	1346	WNW	16	--------	12.6	9.9	.5	1.7	−2.1	77.8	90.4
411	J	Mar. 27	1353	WNW	16	--------	12.6	9.9	2.0	.7	−.6	104.6	117.2
412	G	Mar. 27	1358	WNW	16	--------	12.6	9.9	1.2	3.0	.7	98.8	111.4
413	C	Mar. 27	1401	WNW	8	--------	6.3	4.9	.9	.9	−.6	85.1	91.4
415	E	Mar. 27	1404	WNW	8	--------	6.3	4.9	1.3	.6	−1.7	97.5	103.8
416	G	Mar. 27	1408	WNW	8	--------	6.3	4.9	.6	.3	−1.8	109.2	115.5
417	I	Mar. 27	1409	WNW	8	--------	6.3	4.9	.7	.3	−.6	109.0	115.3
418	F	Mar. 27	1411	WNW	8	--------	6.3	4.9	.7	.3	−1.9	100.7	107.0
419	A	Mar. 27	1413	WNW	8	--------	6.3	4.9	.8	.4	−2.9	89.4	95.7
420	E	Mar. 27	1415	WNW	8	--------	6.3	4.9	1.6	1.9	−.1	94.1	100.4
422	F	Mar. 27	1421	WNW	8	--------	6.3	4.9	1.9	.9	−3.1	101.2	107.5
423	G	Mar. 27	1426	WNW	8	--------	6.3	4.9	1.7	2.9	−.7	105.7	112.0
424	F	Mar. 27	1430	WNW	8	--------	6.3	4.9	.5	−.6	−1.8	93.6	99.9
425	G	Mar. 27	1438	WNW	8	--------	6.3	4.9	.9	−2.3	−3.7	99.1	105.4
426	G	Mar. 27	1440	WNW	8	--------	6.3	4.9	1.0	−.2	−3.1	100.8	107.1
427	E	Mar. 27	1441	WNW	8	--------	6.3	4.9	2.0	--------	------	80.6	86.9
428	E	Mar. 27	1442	WNW	8	--------	6.3	4.9	1.0	−.2	−2.0	83.8	90.1
429	B	Mar. 27	1443	WNW	8	--------	6.3	4.9	.5	.5	−.6	71.9	78.2
430	G	Mar. 27	1452	WNW	8	--------	6.3	4.9	1.6	1.1	−2.4	105.7	112.0
431	F	Mar. 27	1457	WNW	8	--------	6.3	4.9	1.4	.6	−1.1	92.8	99.1
432	B	Mar. 30	1042	NW	26	34	25.1	6.7	.9	−1.7	−1.7	71.4	96.5
433	J	Mar. 30	1044	NW	26	34	25.1	6.7	2.0	−.2	−.2	100.5	125.6
434	E	Mar. 30	1105	WNW	28	38	22.1	17.2	1.5	−.2	−.2	78.0	100.1
435	F	Mar. 30	1109	WNW	28	38	22.1	17.2	.9	2.0	.9	70.0	92.1
436	F	Mar. 30	1114	WNW	28	38	22.1	17.2	1.3	−1.9	−2.6	86.8	108.9
437	B	Mar. 30	1118	WNW	28	38	22.1	17.2	1.2	2.5	−2.6	74.4	96.5
438	B	Mar. 30	1121	WNW	28	38	22.1	17.2	1.7	1.4	−1.0	71.1	93.2
439	F	Mar. 30	1122	WNW	28	38	22.1	17.2	1.2	2.1	.2	64.8	86.9
440	J	Mar. 30	1123	WNW	28	38	22.1	17.2	1.7	2.3	−3.0	88.3	110.4
441	J	Mar. 30	1136	WNW	28	38	22.1	17.2	1.5	1.2	−1.0	75.9	98.0
442	G	Mar. 30	1142	WNW	28	38	22.1	17.2	1.5	−3.6	−.2	91.2	113.3
444	B	Mar. 30	1210	WNW	25	36	19.7	15.4	.5	2.1	−1.8	60.8	80.5
445	G	Mar. 30	1211	WNW	25	36	19.7	15.4	2.7	1.9	−3.1	94.1	113.8
446	F	Mar. 30	1213	WNW	25	36	19.7	15.4	.7	−.2	−.2	70.7	90.4
447	E	Mar. 30	1216	WNW	25	36	19.7	15.4	1.0	2.7	−4.0	81.0	100.7
448	J	Mar. 30	1218	WNW	25	36	19.7	15.4	2.6	--------	------	87.7	107.4
449	E	Mar. 30	1220	WNW	25	36	19.7	15.4	1.4	.8	−.4	83.5	103.2
450	E	Mar. 30	1222	WNW	25	36	19.7	15.4	1.4	−.3	.4	69.7	89.4
451	G	Mar. 30	1225	WNW	25	36	19.7	15.4	.1	−.2	−.7	88.1	107.8
452	H	Mar. 30	1226	WNW	25	36	19.7	15.4	2.2	.2	0	85.2	104.9
453	B	Mar. 30	1232	WNW	25	36	19.7	15.4	2.0	3.9	−3.5	56.2	75.9
454	H	Mar. 30	1237	WNW	25	36	19.7	15.4	.5	.6	−1.2	70.5	90.2
455	H	Mar. 30	1256	WNW	25	36	19.7	15.4	.9	.1	−.4	83.6	103.3
456	A	Mar. 30	1257	WNW	25	36	19.7	15.4	.8	1.4	.4	67.8	87.5
457	E	Mar. 30	1258	WNW	25	36	19.7	15.4	2.6	−4.9	2.6	80.0	99.7
458	J	Mar. 30	1302	NW	28	38	27.0	7.3	1.1	.4	−.4	84.2	111.2
459	I	Mar. 30	1305	NW	28	38	27.0	7.3	1.0	.7	−1.6	85.3	112.3
460	G	Mar. 30	1307	NW	28	38	27.0	7.3	1.6	−2.0	−1.0	90.5	117.5
465	J	Mar. 30	1350	NW	28	38	27.0	7.3	.9	2.3	−.5	83.2	110.2
466	G	Mar. 30	1352	NW	28	38	27.0	7.3	3.8	--------	------	85.0	112.0
468	J	Mar. 30	1358	NW	28	38	27.0	7.3	.9	.2	1.4	85.8	112.8
469	F	Mar. 30	1409	NW	24	33	23.2	6.2	1.5	−2.0	−.7	76.5	99.7
470	G	Mar. 30	1410	NW	24	33	23.2	6.2	1.1	−.8	−.9	86.9	110.1
472	E	Mar. 30	1415	NW	24	33	23.2	6.2	2.7	.8	−.9	78.8	102.0
475	B	Mar. 30	1421	NW	24	33	23.2	6.2	.8	.5	−.9	78.8	102.0

[a] Positive values—head wind.
[b] Positive values—rolling in direction of first wheel to touch.
[c] Positive values—right bank.

TABLE II—Continued

VALUES OF CONTACT CONDITIONS AND OTHER PERTINENT DATA FOR TRANSPORT LANDINGS

Landing number	Airplane type	Date of landing	Time of landing	Wind direction	Wind velocity, mph	Maximum gust velocity, mph	Parallel wind component, mph [a]	Cross-wind component, mph	Sinking speed, fps	Rolling velocity, deg/sec [b]	Bank angle, deg [c]	Forward ground speed, mph	Airspeed, mph
477	B	Mar. 30	1427	NW	24	33	23.2	6.2	0.7	−0.5	−2.5	72.8	96.0
479	E	Mar. 30	1437	NW	24	33	23.2	6.2	3.4	.5	−.7	71.4	94.6
480	G	Mar. 30	1443	NW	24	33	23.2	6.2	.6	1.5	.4	84.4	107.6
481	E	Mar. 30	1445	NW	24	33	23.2	6.2	2.1	1.0	−.1	66.5	89.7
482	F	Mar. 30	1446	NW	24	33	23.2	6.2	1.3	−1.2	−.9	67.8	91.0
485	J	Apr. 2	1118	NW	16	27	15.5	4.1	.1	−.1	−1.2	91.0	106.5
486	E	Apr. 2	1132	NW	16	27	15.5	4.1	1.7	−.5	−.3	81.6	97.1
487	G	Apr. 2	1140	NW	16	27	15.5	4.1	.5	----------	----------	96.0	111.5
488	J	Apr. 2	1143	NW	16	27	15.5	4.1	2.1	−1.7	.1	98.4	113.9
490	J	Apr. 2	1150	NW	16	27	15.5	4.1	1.6	.7	−.3	96.3	111.8
491	H	Apr. 2	1152	NW	16	27	15.5	4.1	1.6	−2.2	.4	94.7	110.2
492	F	Apr. 2	1154	NW	16	27	15.5	4.1	.8	−.4	.4	80.8	96.3
493	F	Apr. 2	1158	NW	16	27	15.5	4.1	1.7	−.5	−.4	89.0	104.5
494	B	Apr. 2	1202	WNW	18	----------	14.2	11.1	.8	0	−1.1	74.0	88.2
495	B	Apr. 2	1205	WNW	18	----------	14.2	11.1	.5	.9	−1.9	66.0	80.2
496	E	Apr. 2	1211	WNW	18	----------	14.2	11.1	.6	−.6	−.2	97.2	111.4
497	G	Apr. 2	1213	WNW	18	----------	14.2	11.1	1.6	----------	----------	85.9	100.1
498	F	Apr. 2	1215	WNW	18	----------	14.2	11.1	.5	.3	−1.0	84.2	98.4
499	B	Apr. 2	1218	WNW	18	----------	14.2	11.1	1.6	−.8	−1.5	70.2	84.4
500	E	Apr. 2	1224	WNW	18	----------	14.2	11.1	1.7	1.5	−2.1	81.0	95.2
501	J	Apr. 2	1226	WNW	18	----------	14.2	11.1	.2	.6	−.4	99.3	113.5
502	H	Apr. 2	1232	WNW	18	----------	14.2	11.1	1.0	−.5	.4	89.4	103.6
503	E	Apr. 2	1235	WNW	18	----------	14.2	11.1	1.7	1.3	−.9	81.6	95.8
504	J	Apr. 2	1240	WNW	18	----------	14.2	11.1	.6	.3	−1.0	90.8	105.0
506	E	Apr. 2	1251	WNW	18	----------	14.2	11.1	.8	−1.8	−.1	74.8	89.0
507	H	Apr. 2	1254	WNW	18	----------	14.2	11.1	1.1	−1.1	2.3	76.6	90.8
508	G	Apr. 2	1255	WNW	18	----------	14.2	11.1	.7	−.5	−1.1	94.3	108.5
509	B	Apr. 2	1300	NW	16	----------	15.5	4.1	.6	.4	0	79.3	94.8
510	J	Apr. 2	1302	NW	16	----------	15.5	4.1	1.1	0	.1	93.9	109.4
511	G	Apr. 2	1304	NW	16	----------	15.5	4.1	.9	.4	−.9	105.4	120.9
512	G	Apr. 2	1307	NW	16	----------	15.5	4.1	1.8	.4	−1.0	91.4	106.9
513	H	Apr. 2	1308	NW	16	----------	15.5	4.1	1.8	.3	−1.6	97.8	113.3
514	K	Apr. 2	1319	NW	16	----------	15.5	4.1	1.0	−.7	1.2	112.7	128.2
515	J	Apr. 2	1322	NW	16	----------	15.5	4.1	1.4	.4	−.3	89.8	105.3
516	B	Apr. 2	1330	NW	16	----------	15.5	4.1	.5	.4	.1	77.8	93.3
519	G	Apr. 2	1355	NW	16	----------	15.5	4.1	1.0	.8	.7	103.3	118.8
521	I	Apr. 2	1357	NW	16	----------	15.5	4.1	1.0	−1.2	1.0	94.1	109.6
522	B	Apr. 2	1400	NNW	15	----------	14.8	2.1	1.0	----------	----------	63.9	78.7
523	B	Apr. 2	1404	NNW	15	----------	14.8	2.1	1.5	.9	−.4	75.4	90.2
524	J	Apr. 2	1405	NNW	15	----------	14.8	2.1	1.3	.4	−.7	98.0	112.8
525	F	Apr. 2	1408	NNW	15	----------	14.8	2.1	1.2	−1.0	.3	82.2	97.8
526	G	Apr. 2	1410	NNW	15	----------	14.8	2.1	1.0	−.8	−.5	97.1	111.9
527	E	Apr. 2	1413	NNW	15	----------	14.8	2.1	1.4	.2	.5	84.8	99.6
528	A	Apr. 2	1425	NNW	15	----------	14.8	2.1	1.1	1.0	−.7	77.2	92.0
529	E	Apr. 2	1426	NNW	15	----------	14.8	2.1	1.5	−.2	−1.0	79.9	94.7
530	G	Apr. 2	1431	NNW	15	----------	14.8	2.1	1.8	.2	1.2	85.2	100.0
531	G	Apr. 2	1434	NNW	15	----------	14.8	2.1	1.2	−.5	−.8	93.5	108.3
532	B	Apr. 2	1436	NNW	15	----------	14.8	2.1	1.0	.1	−.2	72.6	87.4
533	F	Apr. 2	1438	NNW	15	----------	14.8	2.1	1.3	.4	−.7	85.8	100.6
534	F	Apr. 2	1445	NNW	15	----------	14.8	2.1	1.8	−.4	.8	79.6	94.4
535	A	Apr. 2	1448	NNW	15	----------	14.8	2.1	.4	−2.3	−.5	84.3	99.1
536	E	Apr. 2	1449	NNW	15	----------	14.8	2.1	2.6	−.4	−1.2	72.0	86.8
537	A	Apr. 2	1450	NNW	15	----------	14.8	2.1	1.9	.2	0	76.3	91.1
540	F	Apr. 2	1459	NNW	15	----------	14.8	2.1	1.1	−.6	−1.3	87.5	102.3
541	J	Apr. 2	1505	NW	12	----------	11.6	3.1	1.2	.2	1.1	103.3	114.9
545	F	Apr. 8	1417	NW	6	----------	5.8	1.2	1.0	.1	−.6	98.0	103.8
546	F	Apr. 8	1424	NW	6	----------	5.8	1.2	.4	−.6	−.2	96.2	102.0
548	C	Apr. 8	1426	NW	6	----------	5.8	1.2	.8	−2.8	−.8	90.1	95.9
549	B	Apr. 8	1429	NW	6	----------	5.8	1.2	.6	.5	.5	75.4	81.2
550	F	Apr. 8	1436	NW	6	----------	5.8	1.2	.5	−.5	−.1	91.3	97.1
551	G	Apr. 8	1440	NW	6	----------	5.8	1.2	1.0	----------	----------	107.3	113.1
552	F	Apr. 8	1446	NW	6	----------	5.8	1.2	1.1	.4	−.1	79.8	85.6
553	A	Apr. 8	1457	NW	6	----------	5.8	1.2	.9	----------	----------	98.3	104.1
554	J	Apr. 8	1459	NW	6	----------	5.8	1.2	1.0	----------	----------	105.8	111.6
556	A	Apr. 14	1031	WNW	26	36	20.5	16.0	1.3	4.7	−1.9	72.0	92.5
557	J	Apr. 14	1042	WNW	26	36	20.5	16.0	1.5	−.1	−4.0	106.2	126.7
558	B	Apr. 14	1045	WNW	26	36	20.5	16.0	1.3	.5	−.3	70.5	91.0
561	F	Apr. 14	1051	WNW	26	36	20.5	16.0	2.4	−2.5	−4.2	88.5	109.0
562	E	Apr. 14	1100	WNW	26	38	20.5	16.0	.7	----------	----------	73.5	94.0
563	E	Apr. 14	1105	WNW	26	38	20.5	16.0	2.1	1.8	−1.6	92.2	112.7

[a] Positive values—head wind.
[b] Positive values—rolling in direction of first wheel to touch.
[c] Positive values—right bank.

TABLE II—Concluded

VALUES OF CONTACT CONDITIONS AND OTHER PERTINENT DATA FOR TRANSPORT LANDINGS

Landing number	Airplane type	Date of landing	Time of landing	Wind direction	Wind velocity, mph	Maximum gust velocity, mph	Parallel wind component, mph [a]	Cross-wind component, mph	Sinking speed, fps	Rolling velocity, deg/sec [b]	Bank angle, deg [c]	Forward ground speed, mph	Airspeed, mph
564	J	Apr. 14	1115	WNW	26	38	20.5	16.0	1.4	1.3	−0.4	100.4	120.9
565	H	Apr. 14	1119	WNW	26	38	20.5	16.0	3.1	1.0	−.4	85.7	106.2
566	J	Apr. 14	1120	WNW	26	38	20.5	16.0	1.7	--------	------	74.5	95.0
567	B	Apr. 14	1121	WNW	26	38	20.5	16.0	2.3	--------	------	55.3	75.8
568	F	Apr. 14	1122	WNW	26	38	20.5	16.0	2.6	2.0	−2.2	85.5	106.0
570	G	Apr. 14	1128	WNW	26	38	20.5	16.0	1.1	−2.1	−2.0	101.3	121.8
571	B	Apr. 14	1131	WNW	26	38	20.5	16.0	1.4	−3.3	−3.2	58.1	78.6
572	E	Apr. 14	1133	WNW	26	38	20.5	16.0	3.4	4.1	−2.0	81.7	102.2
574	I	Apr. 14	1138	WNW	26	38	20.5	16.0	2.2	1.5	−2.0	76.6	97.1
575	G	Apr. 14	1151	WNW	26	38	20.5	16.0	.4	1.4	.2	85.2	105.7
576	B	Apr. 14	1200	WNW	27	38	21.3	16.6	.4	−.8	−2.9	80.7	102.0
577	F	Apr. 14	1204	WNW	27	38	21.3	16.6	1.7	--------	------	80.5	101.8
578	J	Apr. 14	1212	WNW	27	38	21.3	16.6	2.0	−3.0	.3	108.3	129.6
581	B	Apr. 14	1221	WNW	27	38	21.3	16.6	1.0	--------	------	74.2	95.5
583	E	Apr. 14	1223	WNW	27	38	21.3	16.6	1.5	--------	------	89.8	111.1
585	I	Apr. 14	1226	WNW	27	38	21.3	16.6	2.0	2.3	−2.0	88.5	109.8
587	J	Apr. 14	1237	WNW	27	38	21.3	16.6	2.3	2.0	−1.8	95.7	117.0
588	J	Apr. 14	1238	WNW	27	38	21.3	16.6	1.4	--------	------	100.8	122.1
589	H	Apr. 14	1245	WNW	27	38	21.3	16.6	2.1	.4	−.1	81.5	102.8
590	A	Apr. 14	1252	WNW	27	38	21.3	16.6	.7	2.8	−3.8	69.9	91.2
591	J	Apr. 14	1256	WNW	27	38	21.3	16.6	1.1	.7	−.6	101.1	122.4
592	B	Apr. 14	1258	WNW	27	38	21.3	16.6	.5	1.2	−2.2	81.8	103.1
593	E	Apr. 14	1302	WNW	25	34	19.7	15.4	1.8	2.3	−.5	83.6	103.3
594	G	Apr. 14	1304	WNW	25	34	19.7	15.4	1.4	0	−2.2	96.0	115.7
595	F	Apr. 14	1308	WNW	25	34	19.7	15.4	2.4	--------	------	90.8	110.5
596	K	Apr. 14	1310	WNW	25	34	19.7	15.4	.9	0	−2.0	102.7	122.4
597	G	Apr. 14	1312	WNW	25	34	19.7	15.4	1.0	--------	------	97.8	117.5
600	G	Apr. 14	1343	WNW	25	34	19.7	15.4	.6	2.7	−2.4	102.2	121.9
601	B	Apr. 14	1345	WNW	25	34	19.7	15.4	.9	--------	------	69.4	89.1
602	E	Apr. 14	1349	WNW	25	34	19.7	15.4	.3	3.8	−3.4	75.8	95.5
603	E	Apr. 14	1354	WNW	25	34	19.7	15.4	.8	--------	------	80.6	100.3
604	G	Apr. 14	1355	WNW	25	34	19.7	15.4	.8	−.2	−.3	83.4	103.1
605	F	Apr. 14	1400	WNW	23	32	18.1	14.2	1.7	0	−2.8	86.4	104.5
606	F	Apr. 14	1410	WNW	23	32	18.1	14.2	.8	--------	------	89.8	107.9
607	G	Apr. 14	1411	WNW	23	32	18.1	14.2	1.3	--------	------	84.5	102.6
608	D	Apr. 14	1414	WNW	23	32	18.1	14.2	1.0	1.6	−2.9	83.9	102.0
610	E	Apr. 14	1419	WNW	23	32	18.1	14.2	1.1	2.4	−4.6	78.1	96.2
611	F	Apr. 14	1421	WNW	23	32	18.1	14.2	1.2	--------	------	85.3	103.4
612	B	Apr. 14	1423	WNW	23	32	18.1	14.2	1.2	−4.4	−2.8	69.3	87.4
613	G	Apr. 14	1425	WNW	23	32	18.1	14.2	1.4	2.2	−2.7	84.5	102.6
616	F	Apr. 14	1434	WNW	23	32	18.1	14.2	.6	.6	−1.2	81.1	99.2
617	G	Apr. 14	1446	WNW	23	32	18.1	14.2	1.0	−.9	−.2	89.8	107.9
618	E	Apr. 14	1449	WNW	23	32	18.1	14.2	2.7	−.8	.1	77.2	95.3
620	F	Apr. 14	1450	WNW	23	32	18.1	14.2	1.1	1.6	.5	70.1	88.2
621	F	Apr. 14	1451	WNW	23	32	18.1	14.2	1.9	1.8	−4.1	81.9	100.0
622	E	Apr. 14	1502	WNW	24	36	18.9	14.8	4.4	−1.7	−2.3	72.7	91.6
623	G	Apr. 14	1503	WNW	24	36	18.9	14.8	3.4	--------	------	105.4	124.3
624	G	Apr. 14	1505	WNW	24	36	18.9	14.8	2.2	−1.0	0	85.0	103.9
625	J	Apr. 14	1507	WNW	24	36	18.9	14.8	2.1	.1	−1.4	90.3	109.2
626	J	Apr. 14	1515	WNW	24	36	18.9	14.8	1.1	.2	−3.0	94.8	113.7
627	G	Apr. 14	1531	WNW	24	36	18.9	14.8	1.2	1.6	−5.6	86.2	105.1
628	F	Apr. 14	1549	WNW	24	36	18.9	14.8	1.9	--------	------	86.5	105.4
631	A	Apr. 14	1557	WNW	24	36	18.9	14.8	1.3	--------	------	87.8	106.7
633	B	Apr. 14	1612	WNW	24	36	18.9	14.8	.9	--------	------	72.6	91.5
634	B	Apr. 14	1615	WNW	24	36	18.9	14.8	.6	−.8	−1.3	75.5	94.4
635	B	Apr. 14	1616	WNW	24	36	18.9	14.8	.4	−2.0	−.4	75.1	94.0
636	E	Apr. 14	1621	WNW	24	36	18.9	14.8	1.4	.1	−2.1	80.2	99.1
638	E	Apr. 14	1626	WNW	24	36	18.9	14.8	2.6	−.2	−1.7	81.4	100.3

[a] Positive values—head wind.
[b] Positive values—rolling in direction of first wheel to touch.
[c] Positive values—right bank.

TABLE III

VALUES OF STATISTICAL PARAMETERS FOR LANDING CONTACT CONDITIONS

(a) Sinking speed

Category	Gust condition	Number of landings	Maximum sinking speed, ft/sec	Mean sinking speed, ft/sec	Standard deviation, σ, ft/sec	Coefficient of skewness, α_3
All airplanes	No gusts	207	3.4	1.22	0.57	0.66
	Gusts	271	4.5	1.50	.76	.79
	Total	478	4.5	1.38	.70	.76
Airplane B	Total	67	2.4	1.00	.48	.88
E		91	4.4	1.65	.82	.74
F		75	3.1	1.34	.63	.48
G		100	3.8	1.39	.66	.91
H		36	4.5	1.58	.85	.83
J		71	2.9	1.47	.64	−.19
Low wing loading (airplanes A, B, C, and D)	No gusts	47	2.4	.95	.48	.82
	Gusts	45	2.3	1.02	.46	.75
	Total	92	2.4	.98	.47	.79
Medium wing loading (airplanes E, F, and G)	No gusts	118	3.4	1.28	.57	.64
	Gusts	148	4.4	1.61	.80	.70
	Total	266	4.4	1.46	.72	.88
High wing loading (airplanes H, I, J, and K)	No gusts	42	2.5	1.32	.60	.20
	Gusts	78	4.5	1.58	.73	.51
	Total	120	4.5	1.49	.69	.53

(b) Bank angle

Category	Gust condition	Number of landings	Maximum bank angle, deg	Mean bank angle, deg	Standard deviation, σ	Coefficient of skewness, α_3
All airplanes	No gusts	182	3.7	1.01	0.80	1.19
	Gusts	231	5.6	1.42	1.14	.97
	Total	413	5.6	1.24	1.03	1.16
Twin-engine airplanes	No gusts	110	3.7	1.11	.90	.98
	Gusts	132	5.6	1.61	1.22	.76
	Total	242	5.6	1.38	1.11	1.06
Four-engine airplanes	No gusts	72	3.1	.87	.58	.97
	Gusts	99	4.2	1.17	.96	1.18
	Total	171	4.2	1.05	.84	1.15

(c) Rolling velocity

Category	Gust condition	Number of landings	Maximum rolling velocity, deg/sec	Mean rolling velocity, deg/sec	Standard deviation, σ	Coefficient of skewness, α_3
Rolling toward first wheel to touch (all airplanes).	No gusts	114	3.5	0.98	0.80	1.07
	Gusts	142	4.7	1.35	1.02	.73
	Total	256	4.7	1.18	.94	.96
Rolling away from first wheel to touch (all airplanes).	No gusts	68	3.1	.87	.73	1.04
	Gusts	89	4.9	1.01	.98	1.59
	Total	157	4.9	.95	.88	1.53

(d) Airspeed at contact

Category	Gust condition	Number of landings	Maximum contact airspeed, percent above stall	Mean contact airspeed, percent above stall	Standard deviation, σ	Coefficient of skewness, α_3
All airplanes	No gusts	207	55.4	28.2	9.58	0.17
	Gusts	271	59.2	29.2	9.67	.20
	Total	478	59.2	28.7	9.62	.16

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